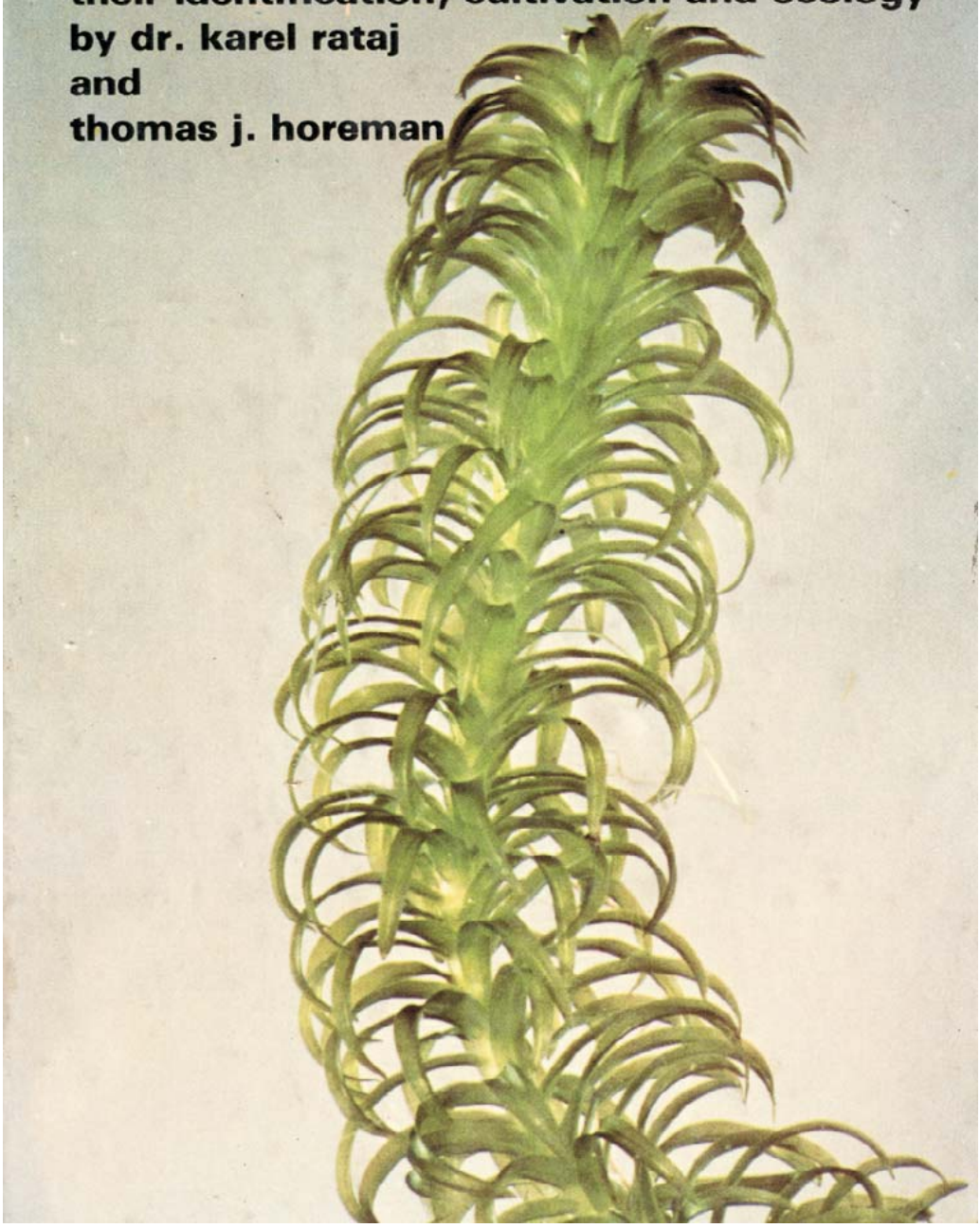
aquarium plants

their identification, cultivation and ecology

by dr. karel rataj
and
thomas j. horeman



AQUARIUM PLANTS

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Cover: *Lagarosiphon major.* Photo by Dr. Herbert R. Axelrod.

Frontispiece: A planted aquarium photographed by Ruda Zukal.

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N.B. *The senior author, Prof. Dr. Karel Rataj, has not been able to verify completely the identification of those photographs credited to Mr. T. Horeman.*

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1

Introduction

This book has been written for lovers of aquariums and terrariums.

Until now the literature dealing with aquarium plants could be divided into two groups. The first group is represented by the numerous books written by educated laymen. In spite of great efforts by their authors, these books usually contain a number of fallacies and errors that are in due course passed on repeatedly by later writers of other books. These errors are commonly found in the descriptions of the biological conditions necessary for cultivating aquatic plants, as well as in the taxonomic sections where incorrect names are used for the species. The second group of books is those written by botanists who have a great deal of knowledge, usually highly specialized, about the cultivation of plants, their structure, and their classification. Unfortunately these authors often lack even a basic understanding of aquarium science, the practical aspect which is of interest to most readers. These often technical books may give a great amount of information on species which cannot even be cultivated under aquarium conditions or, even worse, about plants which turn into pesty weeds that the aquarist finds difficult to remove from his tank.

The authors are aware that this book is incomplete. Some plants cultivated in aquariums have not been described scientifically at the time of writing and only their commercial names can be given. Other groups of plants require a thorough revision before we can be sure of the proper name for the species. In recent years the senior author has revised more than 30,000 herbarium specimens from the major botanical institutes of the world and has described about 30 new species of the genera *Echinodorus, Sagittaria, Aponogeton*, and *Cryptocoryne*, the major groups of aquarium plants. The revised nomenclature of these important genera is presented here for aquarists for the first time.

In addition to general information on raising and identifying aquarium plants, we have also included descriptions of methods used to ensure the reproduction of aquatic plants under cultivation. In many cases these methods are more elaborate than the average aquarist would like. If the major aim of the aquarist is simply raising plants for decorating the aquarium, the best thing to do would be to purchase well developed mature plants from professional cultivators of aquarium plants.

The present book is the joint effort of our chosen specialized fields. Dr. Karel Rataj is a distinguished botanist from Sumperk, Czechoslovakia, who has specialized in the study of the taxonomy and ecology of aquatic plants. Among his many important works might be mentioned his revisions of the important aquarium genera *Echinodorus*, *Cryptocoryne* and *Sagittaria*. Mr. Thomas J. Horeman, of Surrey, England, has made many journeys throughout South America and the Far East to collect aquatic plants. In the course of this activity he has discovered a number of new species, including *Echinodorus horemanii*, and has propagated and distributed them commercially. Thus the reader should be able to profit from the combined experience of both a technical botanist and a practical botanist for the first time in an aquarium book.

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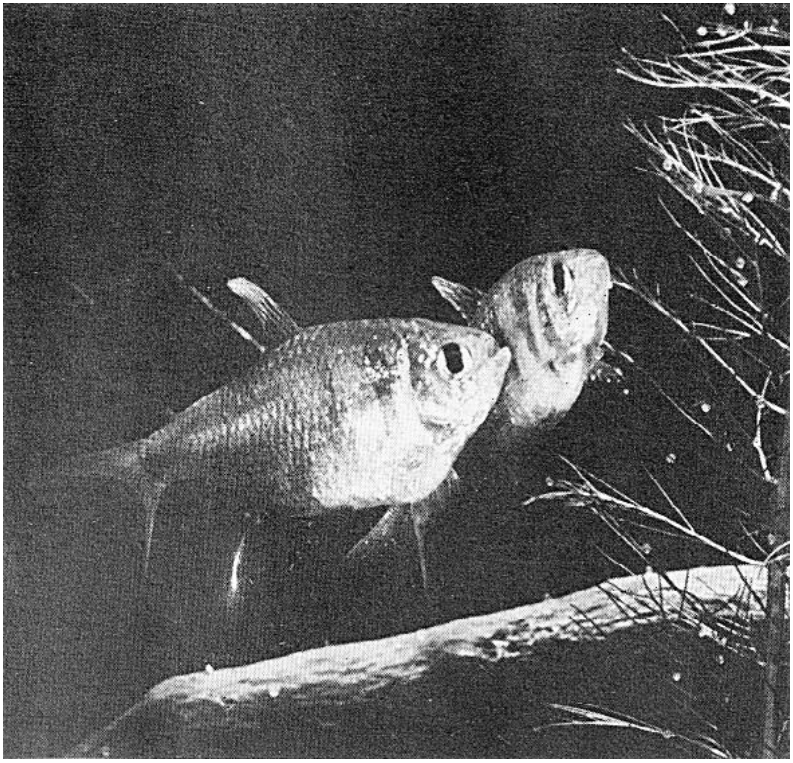
The Importance of Plants in the Aquarium

Biological balance is the basis of a good relationship between living organisms. The aquarium hobby is mostly interested in the keeping of fish in indoor aquariums, but since the lives of fish are closely interwoven with the lives of the plants, aquatic vegetation is an integral part of aquarium science.

Plants are the basis of life on earth. They are producers, the only organisms able to develop organic substances from inorganic mineral elements and their compounds. All animals are consumers, their bodies being unable to utilize inorganic substances directly. The basic food of herbivores is plants, so even the largest carnivorous animals are indirectly dependent on plants. In addition, plants are the greatest single source of oxygen in the atmosphere. Without oxygen animal life on earth would not be possible.

The secret of the remarkable production by plants of both oxygen and organic food substances is of course photosynthesis. During the day the plant consumes nutrients (mineral substances) and obtains carbon dioxide from the atmosphere or from the water, where it has been released as a by-product of animal respiration. In the presence of sunlight and the complex compound chlorophyll, starches and sugars are produced and oxygen eliminated as a waste material. At night the plants reverse their role, breathing in oxygen and eliminating carbon dioxide, but during this time most fish are inactive and their need for oxygen is minimal.

It is not our intention to discuss the details of these fundamental functions of plants and their importance to the aquarium. These are matters well known to everybody, with the details easily available in any basic biology book. We wish to deal first with other principles of aquarium keeping commonly used and readily understood by the aquarist, and then with the cultivation of aquatic plants and their use in the aquarium.



Leafy plants are very useful for the spawning of egg-scattering fish like these tetras (*Hyphessobrycon* species). Those eggs caught among the leaves of the plant usually escape predation by the parent fish. Photo by R. Zukal.

In passing it might be mentioned that many of the aquarium plants described in the following pages are actually amphibious, growing both in and out of the water. If they are carefully watered once a week (even less with some species) they can also be used as potted plants outside the aquarium. The shiny green leaves and often bright infloresences of *Cryptocoryne* are certainly as attractive in the living room as in the aquarium.

Our main goal in writing this book has been to acquaint readers with the practical and, to some extent, theoretical aspects necessary for the choice and cultivation of water plants. If our readers are successful in cultivating even one or two of the more exacting species, we will be satisfied.

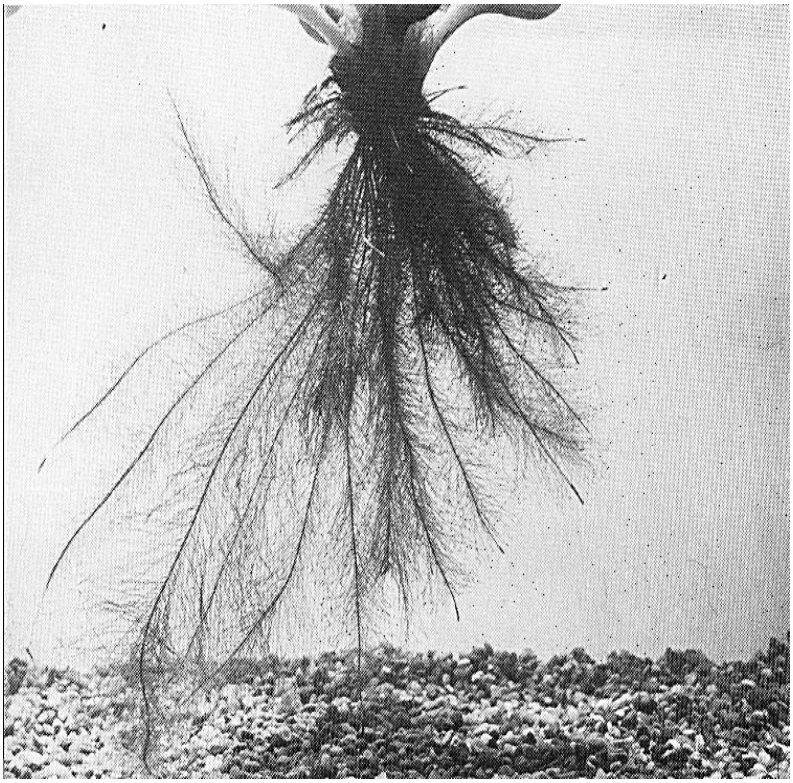
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General Principles for the Cultivation of Aquatic Plants

In order to give aquarium plants a perfectly suitable medium, we must first be aware of the conditions existing in their native habitat. Most aquarium plants come from tropical and subtropical areas, with a few from the warmer parts of the temperate zone. Often the aquarist will see in print or hear in discussions the assumption that tropical soils are fertile and rich in nutrients; this is of course in error. As a rule the soil in the tropics is poor because

Aerial view of Rio Purus, a tributary of the Amazon River, taken during the dry part of the year. Note the great scouring effect of water currents on the banks. Photo by Dr. H.R. Axelrod.





Root system of the water hyacinth (*Eichhornia crassipes*). Photo by Dr. D. Sculthorpe.

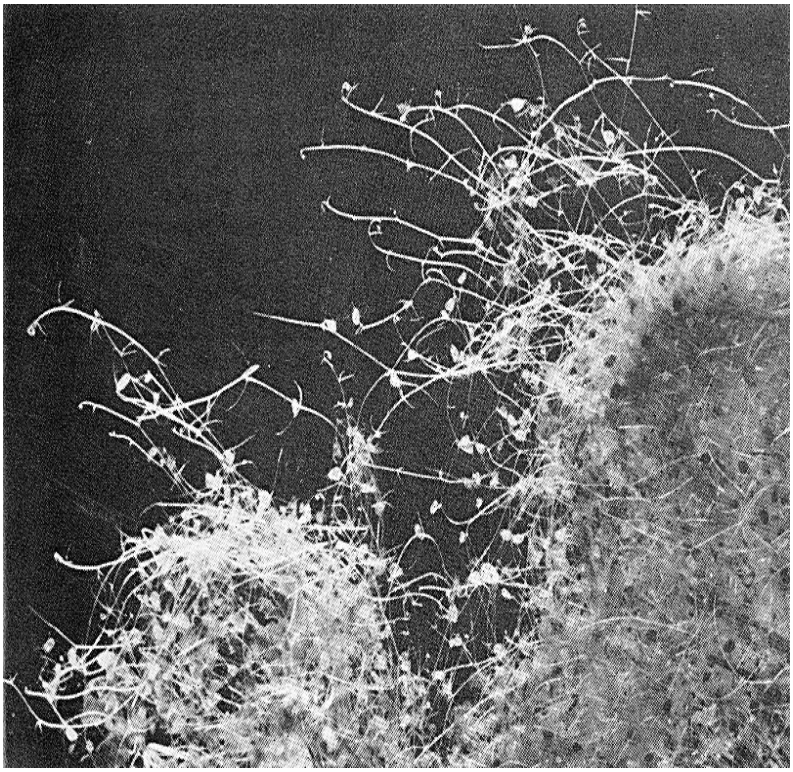
great quantities of organic substances, arising from defoliation and by the death of tropical vegetation, are consumed by the soil organisms so quickly that the decomposition of this material is faster than the rate at which it is replaced. High temperatures and high humidity make possible such a quick decomposition or mineralization of organic substances that the tropical soil is poorer in nutrients than ordinary field soil in temperate climates.

Plants in their natural environments are continually damaged by animals and by weather conditions such as floods. They grow in water that for at least part of the growing period is muddy and full of impurities that settle on the leaves and impede the functioning of the plants. The bottom of tropical pools and streams is often peaty, and peat is of course a very poor source of nutrients.

In the aquarium we cannot adhere to all these natural conditions because in a confined habitat they are obviously detrimental to the plants. Instead we prepare a much better medium which has many of the advantages of the natural environment without its disadvantages.

Unlike most land plants, aquatic plants are not dependent solely on nutrition obtained through the root system. They are able to receive nutrients through the whole surface of the plant body, especially the epidermis of the leaves. Such typically submersed plants as *Ceratophyllum* and *Utricularia* do not form roots at all, while *Elodea* and *Najas* form only very short ones. For this reason the composition of not only the soil but of the water is of great importance, as the water must contain many mineral substances ab-

The leaves of the bladderwort (*Utricularia*) are modified into small bladders capable of ingesting minute organisms like *Daphnia* but not fish fry. Bladderworts do not develop roots.

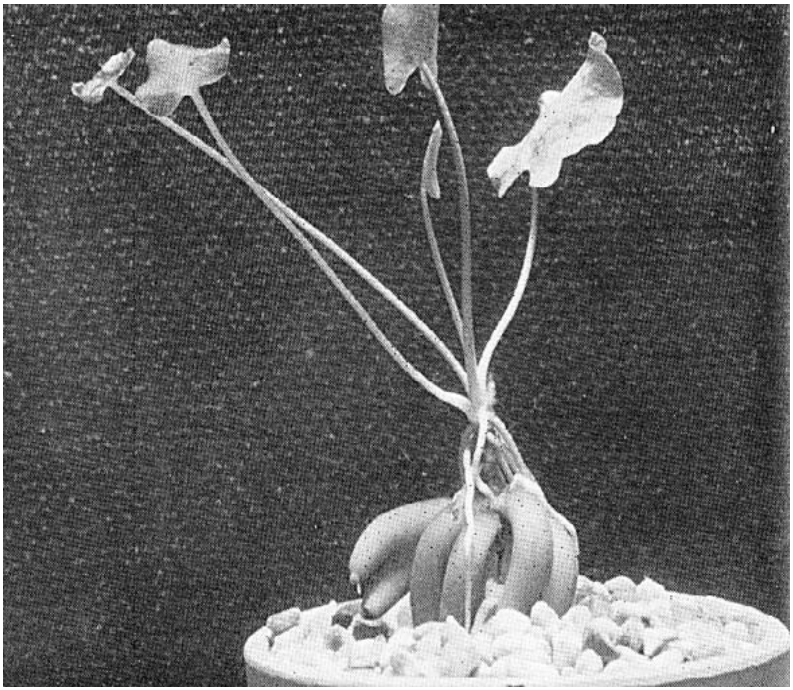


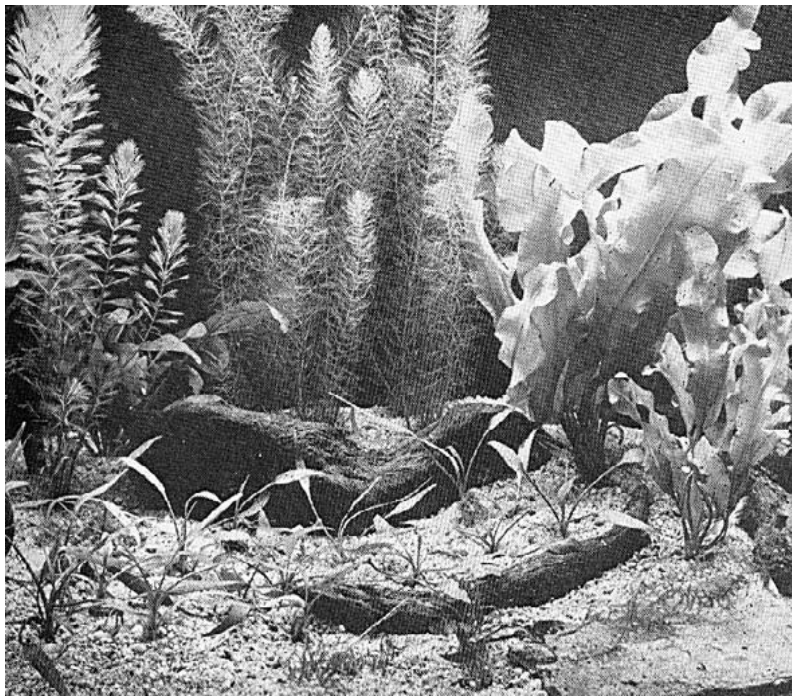
sorbed directly by the plant. This must be taken into consideration when establishing an aquarium and selecting the planting medium.

There has long been a controversy over whether such rooted submersed plants as *Cryptocoryne* and *Echinodorus* receive the majority of their nutrients through the leaves or the roots. Either answer is partially correct, as the method of absorption varies with different concentrations of nutrients in the medium. As a general rule, the more diluted the solution, the more accessible the minerals. If there is a very heavy concentration of nutrients in the soil, only the small percentage dissolved in the water will actually be available to the plant.

Occasionally aquarists have good luck growing plants for several months or longer when using such normally objectionable bottom materials as peat, garden soil, industrial fertilizer, or clay. This is because we are never really quite certain about the proper-

The elongated tubers of the underwater banana plant (*Nymphoides aquatica*) contain reserve food material. Photo by Dr. D. Sculthorpe.





Plants of various species and origin can be combined artistically in a single tank provided their requirements do not conflict.

ties of the substrate just from its name. It is necessary to determine many factors, such as the pH, the proportions of the major nutrients (nitrates, phosphates, etc.), the presence or absence of certain important microelements, the amount of humus, etc. Not many aquarists are able to test for all this necessary information without access to a well equipped laboratory. Commercial soil testing kits are available for some of the substrate components, but not for all.

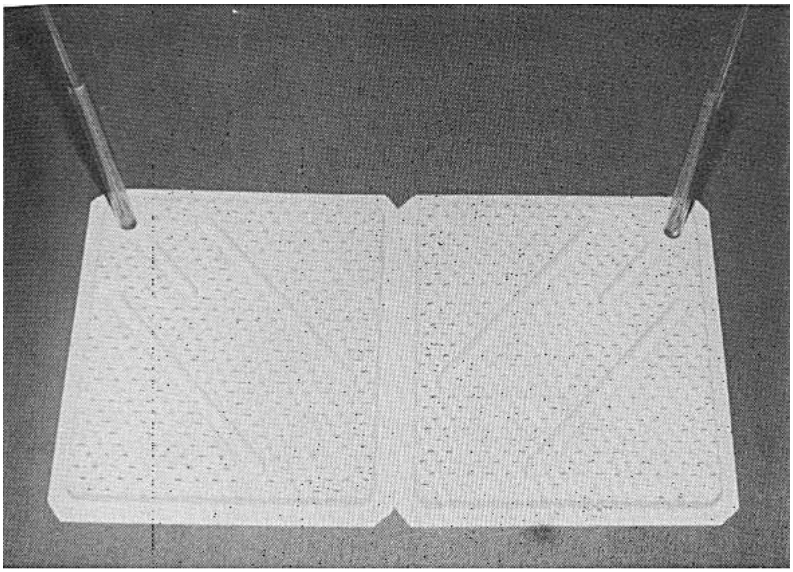
The safest and most uniform method of setting up the planted aquarium is to start off with plain washed sand or gravel and for the first year or so use only plants with strong and well developed rhizomes. The rhizomes should have enough stored food reserves to last the plant at least several months. Good starting plants include the stronger species of *Echinodorus*, *Cryptocoryne*, *Lagenandra*, *Aponogeton*, and *Crinum*. In a newly established aquarium we cannot grow such plants as *Myriophyllum*, *Ludwigia*, or *Cabomba*, as these lack reserve food supplies.

Start the aquarium by purchasing good quality rather coarse sand from a reputable dealer. Make sure the sand is washed clean of all impurities. On the bottom of the aquarium install a good quality undergravel filter to ensure the circulation of the oxygenated water through the sand and around the roots of the plants. This speeds the decomposition of organic substances such as fish feces and food remains to the mineral state and provides a constant temperature throughout the aquarium. By using a sand substrate together with an undergravel filter we can be confident that the water will not contain a surplus of organic substances and will be supplied with sufficient mineral nutrients necessary for the good development of the plants.

To obtain maximum growth and longevity from your plants, the undergravel filter should preferably be the type consisting of numerous small perforated plastic tubes. With this type of filter there is no gap between the base of the aquarium and the sand bed. Thus there is no place for debris to build up where it cannot be decomposed by the proper bacteria in the presence of oxygen. The tube-type filter also has less chance of getting tangled in the growing roots of the plants.

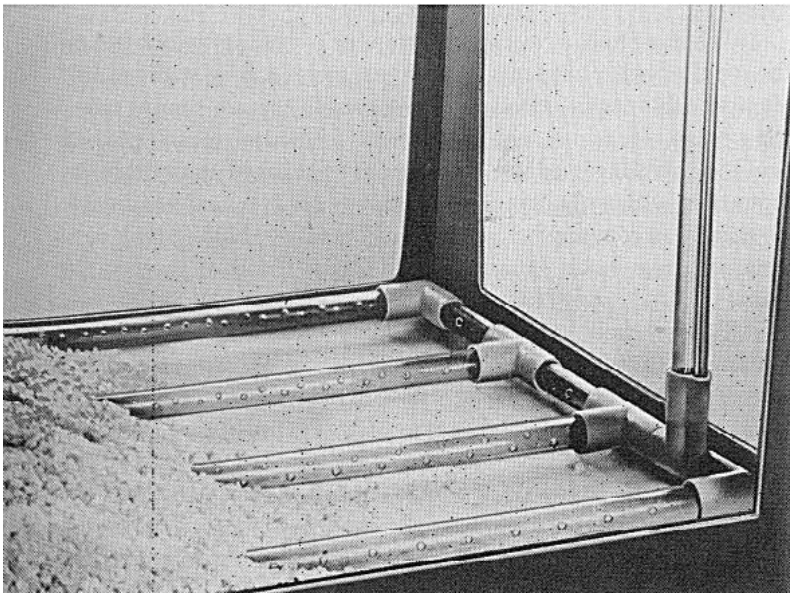
For the first year the substrate is poor in nutrients, but with the passing of time it becomes richer and richer due to the accumulation and decomposition of fish and plant wastes. The type of fish kept can to some extent determine how fast nutrients accumulate, as some fish are naturally "dirtier" than others. Thus most of the live-bearers, including the swordtails, platies, mollies, and guppies, produce dirtier and richer bottoms than the tetras of similar size. In the normal aquarium there is plenty of detritus, usually more than necessary for the plants. It must on occasion be cleaned out, as only the detritus under the surface of the sand is really necessary for the plants to obtain sufficient nutrients. An aquarium two or three years old is an ideal environment for the growth and development of all species of aquatic plants.

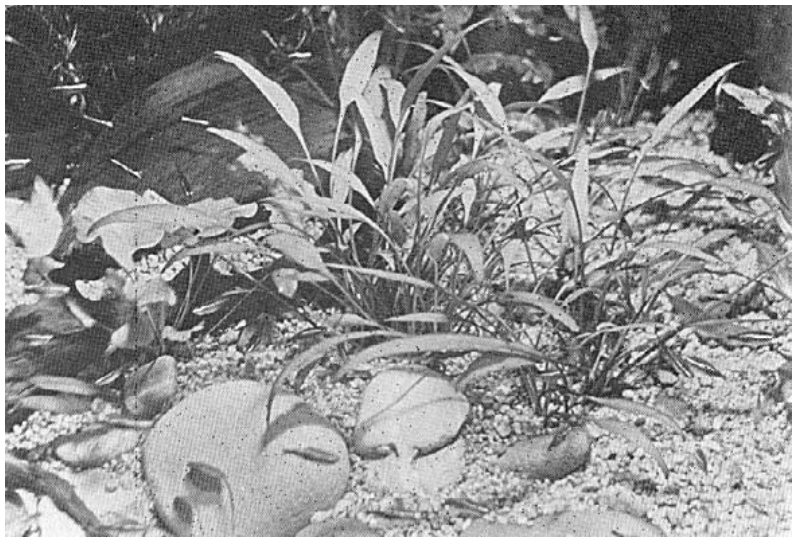
It is important that the detritus in the sand should be decomposed in the presence of oxygen. This decomposition, called aerobic, does not occur when the substrate medium is air-tight. Air-tight media include such things as peat, clay, and garden soil. Anaerobic decomposition (decomposition in the absence of air) results in the formation of poisonous gases such as hydrogen sulphide. These gases appear as bubbles which leak out of the bottom when the plants are pulled out; the roots will be brown or black. Hydrogen sulphide can destroy both plants and fish. Industrial fer-



Inexpensive type of undergravel filter with a continuous base of perforated plastic material.

This undergravel filter consists of a series of parallel rows of perforated plastic tubes. Photo courtesy Eureka Products Company.





A small fish population can provide the plants in an aquarium with enough nutrients so that the addition of fertilizers is truly unnecessary.

tilizers are a source of hydrogen sulphide, so they should not be used in the aquarium. Fish produce enough nutrients for the plants.

When we talk of a *poor* substrate or a medium which has to be supplied with nutrients, we do not mean a base without any compounds or with added fertilizers or soil; we are simply referring to an aquarium with a substrate formed of clean, washed sand. A planting medium in a newly established tank or in an aquarium with a small number of fish is poor. It is *moderately rich* to *rich* when composed of washed sand in an established tank containing a reasonable number of fish for a period of six to eight months.

Readers should not be influenced by various publications and pictures illustrating tiny plants grown in clean sand and giant plants growing in fertilized soil or industrial nutrients. How would such pictures look when taken one, two, or three years later? By then the influence of anaerobic decomposition and poisonous gases will have become obvious. If you do not believe this, just check the aquariums of the professionals who acclimatize newly imported plants—you will find only clean, washed sand, never soil or fertilizers.

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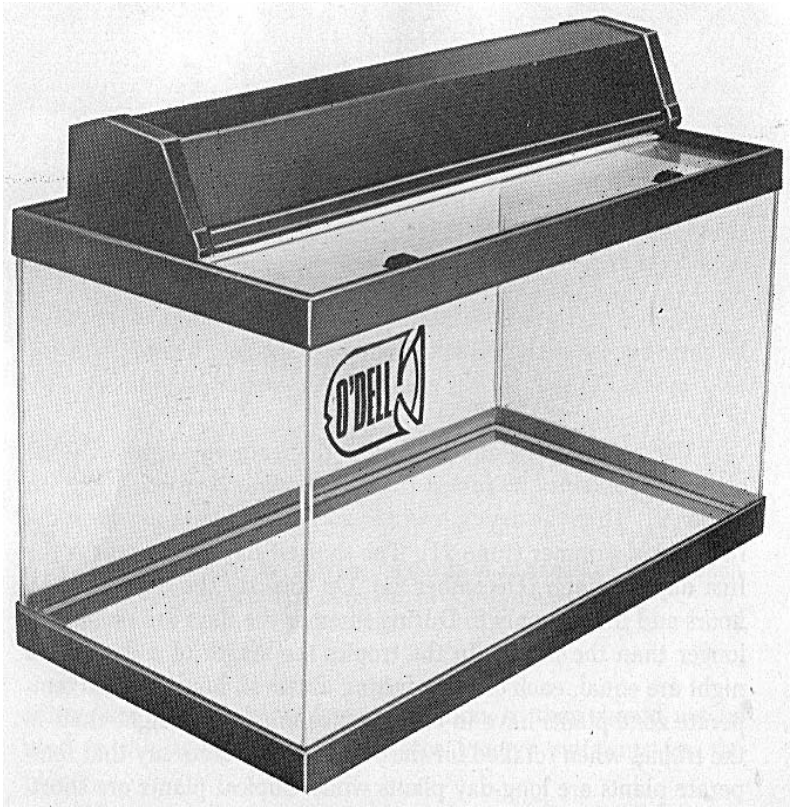
Illumination of the Aquarium

If an aquarium is to fulfill its esthetic function, it must be brightly illuminated. Artificial light is an absolute necessity for the development of plants. It is even more important than the quality of the water.

The length of the day changes in the temperate zone with the change of seasons. In spring the day is as long as the night on March 21. Then the days get longer and are at their longest on the first day of summer (June 21). The shortest day of the year is the first day of winter (December 21). On this day the night lasts 16 hours and the day only 8. During summer the days are essentially longer than the nights. In the tropics the length of a day and a night are equal, each of them lasting about 12 hours. In the temperate zone plants have in consequence much more light than in the tropics when totalled for the year. We therefore say that temperate plants are long-day plants while tropical plants are short-day plants. Only during the time of the spring and autumn equinoxes do our aquariums have a tropical day. For that reason tropical plants usually put out flower buds and flower by slow growth one to three months later. Tropical plants do not mind a longer period of light than they are accustomed to; it even helps speed their growth and the development of roots and leaves.

A long day in the temperate zone does not allow tropical plants to flower, since it acts as a brake on development of the sexual organs. On the other hand, they do not thrive well on a short winter day of 8 to 10 hours. They lose their leaves and some of the more sensitive plants may die. If we want the aquarium to be decorative all year long we must prolong the light period during the winter. The plants require a day of at least 12 hours every day of the year.

The most important principle of aquarium lighting is that the duration of the light is more important than the intensity if everything else is constant. While it is not of drastic importance whether an aquarium is lit with 40, 60, or 100 watt bulbs (presuming the



For safety the lighting system should fit the size and construction of the tank. An ill-fitting and improperly installed lighting set-up can be very dangerous. Courtesy of O'Dell Manufacturing Company.

minimal lighting intensity for the plants is reached), it is essential to consider for how long and at what time they are lit. It has already been stated that tropical plants are short-day plants and require light for 12 hours a day. The necessary hours of light cannot be replaced by more intensive light sources operating for a shorter period of time. It is not necessary to measure the intensity of the light in lux (a unit of illumination equal to 1 lumen per square meter; a lumen is the amount of light which falls on an area of 1 square centimeter placed 1 centimeter from a standard candle) as long as the plants can easily become accustomed to weak or strong light, but tropical plants cannot get used to too short of a day.



A lightmeter can be of great help to those who would like to monitor the light requirements of their plants. Photo by Dr. H.R. Axelrod.

By additional artificial light we mean the *prolongation* of daylight in winter, not the increase of the intensity during the natural day. In practice this means that in winter it is necessary to prolong the plants' day by about 4 hours. It does not matter whether this period of additional light is given in the morning before dawn or in the evening after dusk. It also does not matter whether the 4 hours is given as a unit or divided between morning and evening. In order to keep the plants on a regular rhythm or schedule, the light should be given at the same time each day. Thus the day should not be prolonged in the morning one time and in the evening the next.

If an automatic time switch is available, this greatly simplifies the keeping of a regular lighting schedule. The extra lighting can be turned on automatically at, say, 3:30 p.m. and kept operating until at least 8:00 p.m. If the light can be kept on until 10:00 p.m., so much the better. Plants kept under this schedule will have the same growth rate all year long and will develop as well during the winter as during the summer.

Plants react best to light which is predominantly in the red and blue wavelengths. Such lighting is readily available in the form of special fluorescent tubes, such as the Gro-Lux type, sold in most aquarium and plant shops.

The importance of the length of daylight is often underestimated by aquarists, and we are convinced that failures with some sensitive tropical plants are caused largely by short winter days.



A collector pulling out a *Cryptocoryne* from its shady natural habitat in a small stream in Singapore. Photo by Lee Chin Eng.

DO SHADE-LOVING PLANTS EXIST?

Many experts believe that shade-loving plants do not exist. Among aquarium plants the cryptocorynes have the most familiar reputation as shade-loving plants. It is true that in nature most of them grow mainly in shaded situations where no other low-growing vegetation exists. Do they live in deep shade because it meets their requirements best or because they have been forced there through competition? In our opinion there is no doubt that they have been forced into the shade.

The soil in the tropics is very poor, and plants which grow rapidly do so due to their strong root system. Cryptocorynes have a relatively weak root system and are not able to extract the needed nutrients from the soil. In a natural tropical society of plants cryptocorynes are not able to compete with other, more aggressive spe-

cies which can outgrow and suffocate them. For this reason cryptocorynes have had no other "choice" than to colonize the most shaded situations where competition does not exist. They have a great ability to survive in subdued light. Only in artificial culture can we see how much some cryptocorynes love sunlight and how well some species do under its direct rays.

The same applies to their submersed forms, but only if given the right quality of water. It is not a question here of shade-loving plants but of water in shady areas. In a permanent half-shade or in permanent artificial light water holds its good qualities. If water is alternately sunlit and shaded, sudden changes take place. There are changes in the number and species of protozoans, algae, and bacteria. In consequence both chemical and physical qualities of the water change and these changes effect a negative growth in the development of plants.

Even if the above explanation is nearer to the real situation than most other explanations, nothing changes the fact that the best position for an indoor aquarium is a place away from the window and sunlight. The plants will improve with the assistance of artificial light. The important thing is to prepare the most constant and favorable conditions of development throughout the year. Do not be afraid of plenty of light even with "shade-loving" plants, but protect your aquarium from undesirable fluctuations of light intensity. It has been reliably demonstrated that many shade-loving plants easily become accustomed to a much stronger intensity of light and that plants occurring in nature in constantly lit localities usually become easily accustomed to a constant half-shade in the aquarium. Exceptions will be mentioned with the descriptions of the individual species of plants.

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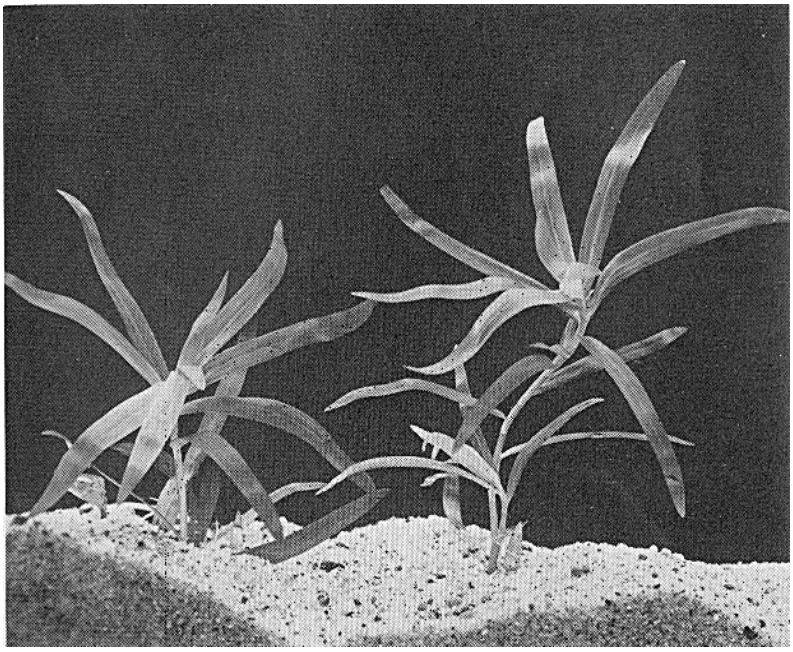
Fully Aquatic and Amphibious Plants in Nature and the Aquarium

In nature aquatic and amphibious plants live in various types of still and moving waters. They are found in or on the banks of rivers, streams, backwaters, ponds, lakes, marshes, and swamps, as well as in man-made irrigation ditches or canals. In some areas of the world these plants are to be found on worked land where marsh culture products such as rice are grown and where various kinds of aquatic and marsh plants occur as weeds.

Every type of natural water is characterized by certain peculiarities which influence to a greater or lesser degree the plant communities existing there. The qualities of these waters and the conditions which they provide for water plants are partly variable, partly invariable. To the constant qualities belong the composition of the substrate (the soil on the bottom) and the quality of the water (nutrients, pH, etc.). The other qualities of the medium are subject to greater change as a rule. These variable factors include the depth of the water, its temperature and transparency, and its velocity, among others.

THE TRANSPARENCY OF THE WATER

Transparency of water depends on the presence of suspended insoluble substances which in turn determine the quantity of light that can penetrate the water surface and make life possible for the plants. Light intensity is especially important in relation to photosynthesis, of course. In waters of high clarity the light penetrates for several meters, as in clear lakes, but in most waters penetration is for only a few meters; in very heavily silted dark waters the light penetrates for a meter or less. Transparency of the water determines not only the depth to which plants can successfully grow,



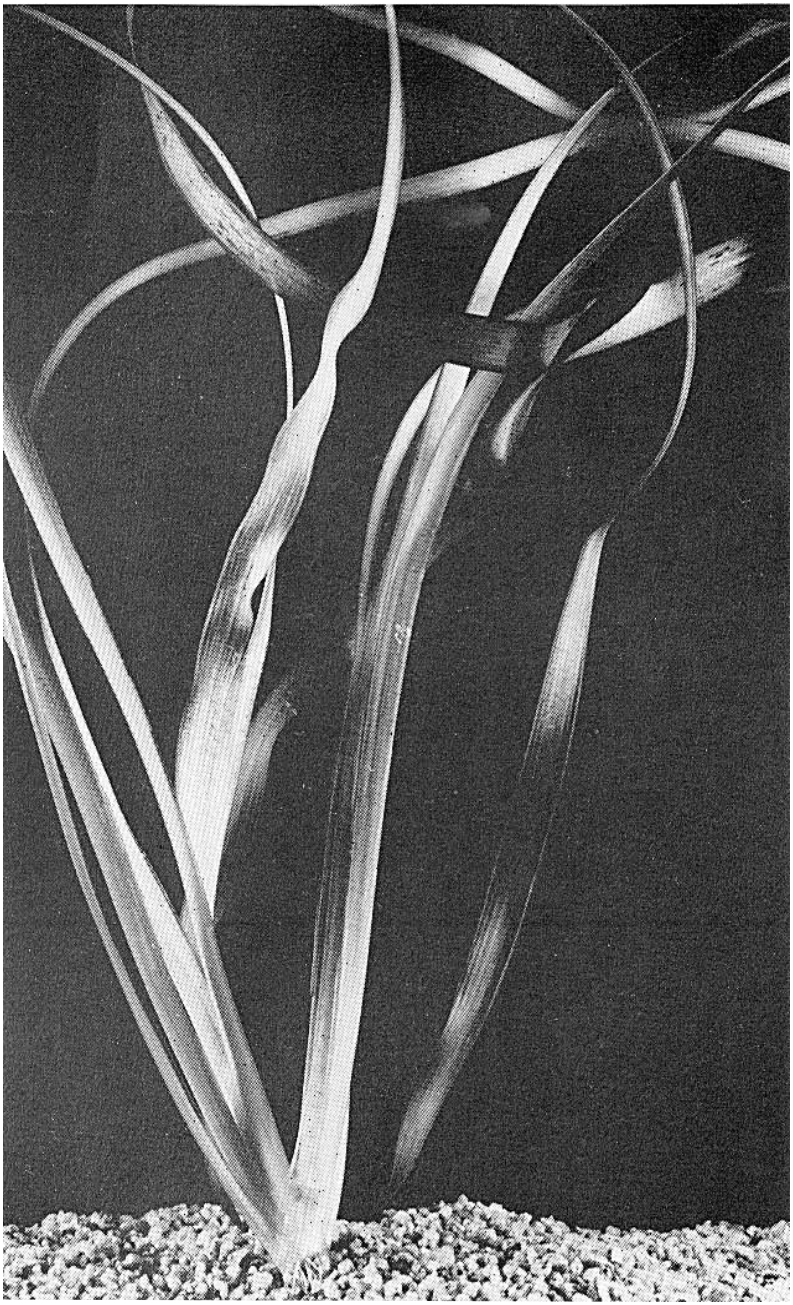
Heteranthera can also be grown successfully outside the water. Photo by G.J.M. Timmerman.

but also some aspects of their coloration. In greater depths or in less translucent waters the plants have a brownish or reddish color mixed with their basic green leaves; in clear waters they are entirely green.

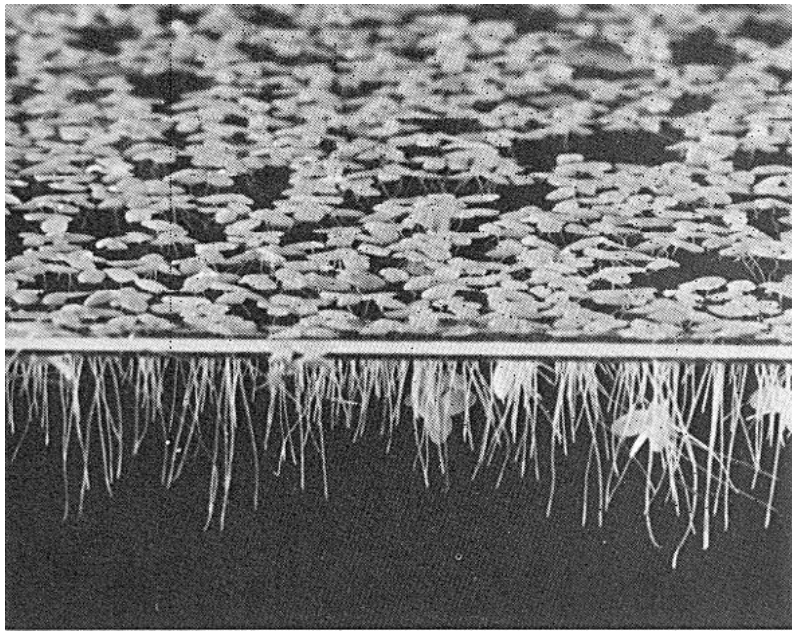
THE DEPTH OF THE WATER

Their depth below the surface often determines the way of life of the plant much as it does their structure and color. In consequence some plants are always found *in the* lower layers of water, while others live rather nearer the surface. Several groups can be distinguished.

1) Submersed plants that are rooted in the bottom and have leaves and *stems* that grow permanently under water. They may also flower under water and produce seeds there. The flowers or leaves do not always reach the surface and are not adapted to a life above water. This group includes many aquarium plants such as *Vallisneria*, *Barclaya*, and *Ottelia*.



Vallisneria is a completely submersed form of plant. This plant is not recommended for small tanks.

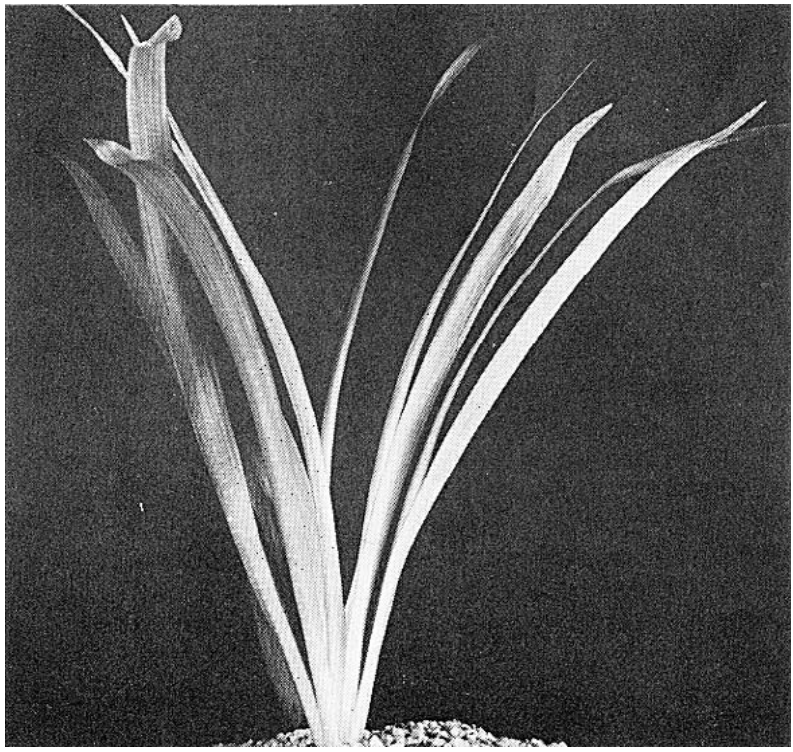


Lemna is a floating type of plant found in ponds and quiet streams. Removal of excess growth in aquariums is recommended for this prolific plant.

2) Plants rooted in the bottom but with leaves reaching the water surface. They usually have well developed roots and fragile stems with which to resist the pressure of the current. They flower as a rule above the water surface and, unlike the preceding group, they develop more conspicuous flowers. Land forms can develop. *Myriophyllum* and *Heteranthera*, among others, are representative of this group.

3) Floating plants that live in the surface layer of the water. Their roots float freely and their leaves may be on the surface, as in *Lemna* and *Limnobium*, under water, as in *Utricularia*, or above water, as in *Eichhornia*. The flowers are always above water and are pollinated in the air.

4) Amphibious plants that can grow under water as well as on dry land. In the water they develop submersed as well as floating leaves and/or emersed aerial leaves. When the water dries, land forms arise. These are mainly bankside plants, of which many are important in the aquarium. Typical genera include *Echinodorus*, *Sagittaria*, and *Cryptocoryne*.



Sagittaria, being an amphibious form, grows under water as well as on land.

THE NUTRIENTS IN THE WATER

The minerals necessary to plants are termed nutrients. Every species has its own special requirements, although a large number of species will need the same materials in about the same proportions. Natural waters contain certain groups or proportions of mineral elements, and plants have evolved in such a way as to be able to occupy waters containing certain concentrations of minerals. It is possible to classify natural water in several groups, each according to its nutritional value.

1) Waters poor in nutrients (oligotrophic) and containing less than 0.01g dissolved material per liter. In waters like these relatively few plants grow, and all are specialized.

2) Waters rich in organic substances and inhabited largely by amphibious plants with emersed leaves. For submersed plants such



Asian fish dealers utilize water hyacinth (*Eichhornia*) to protect their fish from too much light. Photo by Lee Chin Eng.

waters are mostly unsuitable. These organically rich waters arise in the aquarium if a planting medium rich in humus, such as horticultural soil or peat, is used. Submersed leaves usually become unkempt and then decay.

3) Waters rich in mineral substance (eutrophic) and having plenty of basic mineral nutrients and a very small quantity of organic substances. This is the most suitable water for the aquarium containing clean, washed sand. Fish feces fall into the sand and decompose into mineral substances. A biological filter which accelerates the decomposition of organic substances into mineral ones helps greatly.

4) Waters with a superabundance of mineral substances (brackish) are found on soils rich in salts and at the mouth of rivers entering the sea. Few species grow here, and they are generally specialized and unsuitable for the aquarium.

TEMPERATURE AND HEATING OF THE AQUARIUM

Aquariums are generally heated for the benefit of the fish, not the plants. Tropical plants usually need temperatures ranging from 66° to 77° F (19° to 25° C), which fortunately corresponds to the requirements of tropical fish. Aquatic plants from the temperate zone can all stand temperatures of about 68° F (20° C) except those from cold spring waters, which are not recommended for home aquariums anyway.

It is not necessary to go into details of water temperature in relation to their cultivation in aquariums with a temperature of 68° to 77° F (20° to 25° C). If we have an aquarium with fish from the temperate zone, the aquarium being left unheated in the winter and reaching low temperatures of 50° to 59° F (10° to 15° C), we should likewise use temperate plants from Europe and North America. At the other extreme are spawning aquariums where the temperature is often increased to 82° to 86° F (28° to 30° C); here only tropical plants can be used, as temperate or subtropical species die at such high temperatures.

For the greatest efficiency in heating, tubular submersed heaters should be used. These should be installed in the aquarium when the sand bottom is added and should preferably be covered by the sand. In this way uniform heating of all the water occurs as does heating of the substrate. Thus the plants have a constant temperature in both leaves and roots. Short heaters set vertically may heat only the water near the surface, while the bottom water and sand remain cold. By introducing circulation of the water through a filter or by heavy aeration, a uniform temperature is reached in the water but the substrate remains cold. In a cold medium the plant roots reduce their activities and assimilate a smaller amount of nutrients than is needed by the leaves, which are functioning in warm water. Cryptocorynes are very sensitive to these temperature differentials. We are convinced that this is a very frequent cause of "*Cryptocoryne* disease."

An undergravel filter draws the water through the sand substrate, removing temperature differences between the water and the sand bottom. The temperature of the whole plant body is thus about the same, a factor which favors the prosperous development of the plant.

6

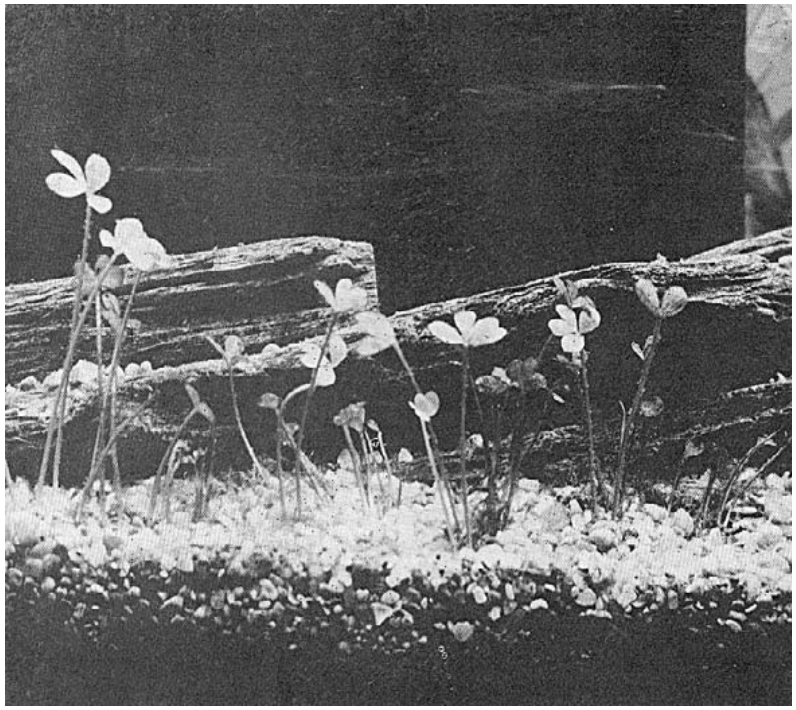
The Arrangement of Indoor Aquariums

Although an indoor aquarium can be designed and maintained for any of several purposes, it should always be attractive. The design and planting should not only suit the needs of the plants and fish but should also be as perfect as possible esthetically.

Clean, washed sand, rather coarse in texture, is the most suitable substrate material for the aquarium. The surface of the bottom material should not be flat, but should slope down toward the front, terrace-like, with some irregular indentations. It should be reinforced and decorated with rocks of various sizes. The only suitable rocks are those made of hard and insoluble materials which will not change the quality of the water. Limestone and sandstone are quite unsuitable. The most commonly used rocks are those composed of silica, quartz, granite, slate, and other similarly stable materials. In order to present a natural impression the rocks should be of a uniform type; if they vary in color the aquarium will appear unnatural.

In addition to rocks, such items as old branches, parts of tree trunks, and stumps are all useful decorative material in the aquarium. Any wood placed in the tank should be neither fresh nor rotten. Old pieces of trees which have lain for years in a pond and are impregnated with mineral substances from the water are best. These will usually be very hard and dark. Old jagged roots dug from peat bogs are especially good.

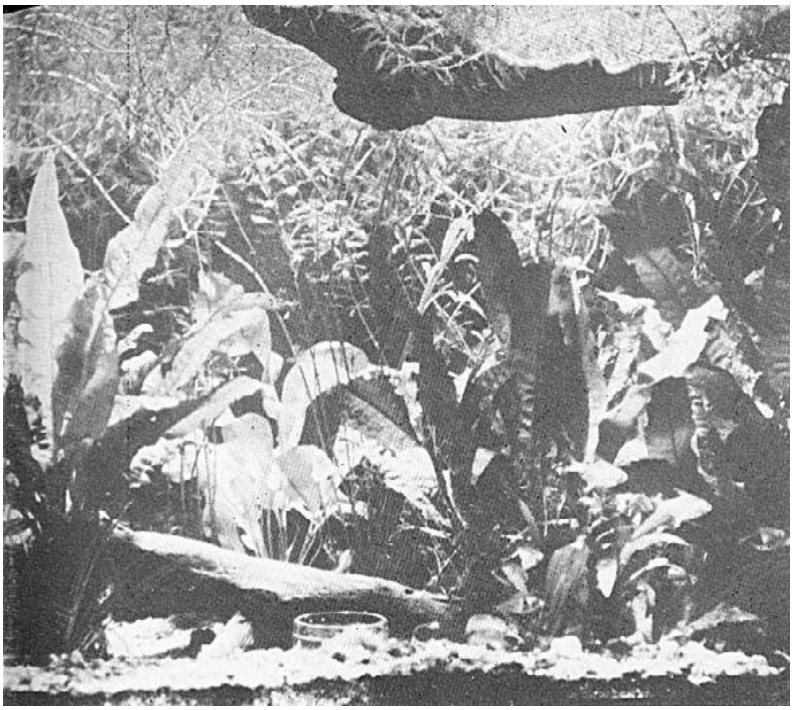
The aquarium is not a copy of nature. We do not usually choose plants according to their geographical distribution, but instead try to build up a collection of plants which will thrive in the aquarium conditions we are able to give them. Thus the temperature, light, available space, available nutrients, pH, and similar factors determine to a great extent which plants can be kept in a specific aquarium.



Marsilea, greatly resembling the ordinary four-leaf clover, can enhance the beauty of the fore part of the tank with a low layer of green growth. Photo by Dr. D. Sculthorpe.

It also goes without saying that the density and kind of growth is chosen according to whether or not the aquarium will be inhabited by fish and the kinds and number of fish kept. In accordance with this, the types of plantings for aquariums can be divided into several groups.

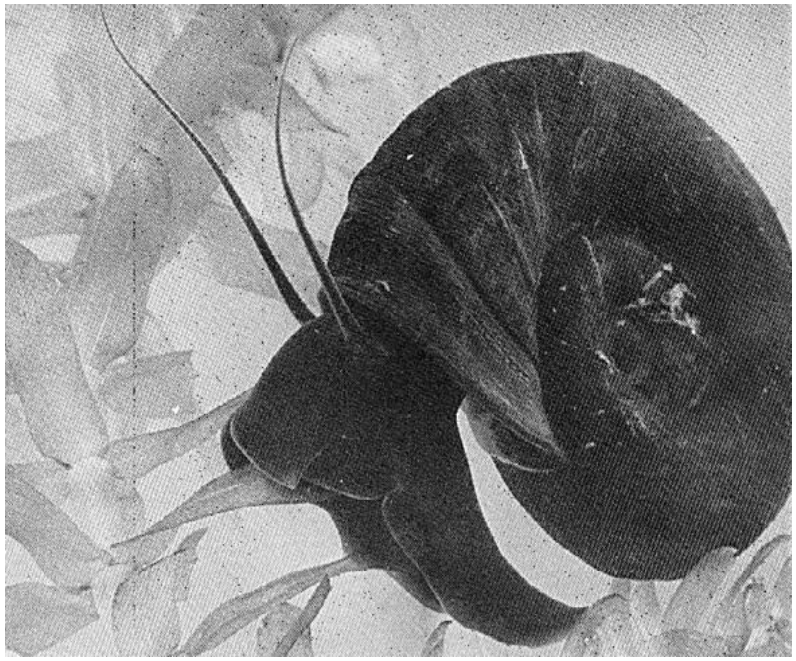
1) The aquarium as a decoration, without fish. This aquarium is a tasteful ornament which, in conjunction with suitably chosen floral decorations, will create a pleasant appearance in the home. Such an aquarium requires less care than ordinary indoor pot-plants and should be a part of the decor of every home that has central heating, as it helps reduce moisture lost to the heating system. An indoor aquarium often enables one to cultivate those plants which cannot stand dry air and which do not thrive in a room with central heating.



The beauty of a planted tank can be maintained by the regular removal of excess growth. Some species grow at a much faster rate than others depending on the light and nutrient conditions in the tank.

This type of aquarium is usually planted with the least exacting plants, mainly those that propagate vegetatively. Often only a single species is used; *Vallisneria* with spirally coiled leaves (*V. americana*) is recommended. This plant grows abundantly over the whole aquarium and produces fine visual effects with an underwater light source.

In addition it is possible to furnish the bottom with low-growing plants to cover the whole floor of the aquarium and create a lower layer of vegetation. Here *Sagittaria subulata, Marsilea browni, Echinodorus quadricostatus*, or *E. tenellus* is suitable. The green carpet on the bottom is complemented by plants with long floating and densely leaved stems (*Myriophyllum, Anacharis, Elodea, Egeria, Lagarosiphon*) or with 2 or 3 tufts of a large-leaved plant whose leaves reach the water surface and do not develop from rhizomes or root runners (*Aponogeton, Echinodorus*).



Some plants can be ruined by freshwater snails such as *Planorbis*. Photo by M. Chvojka.

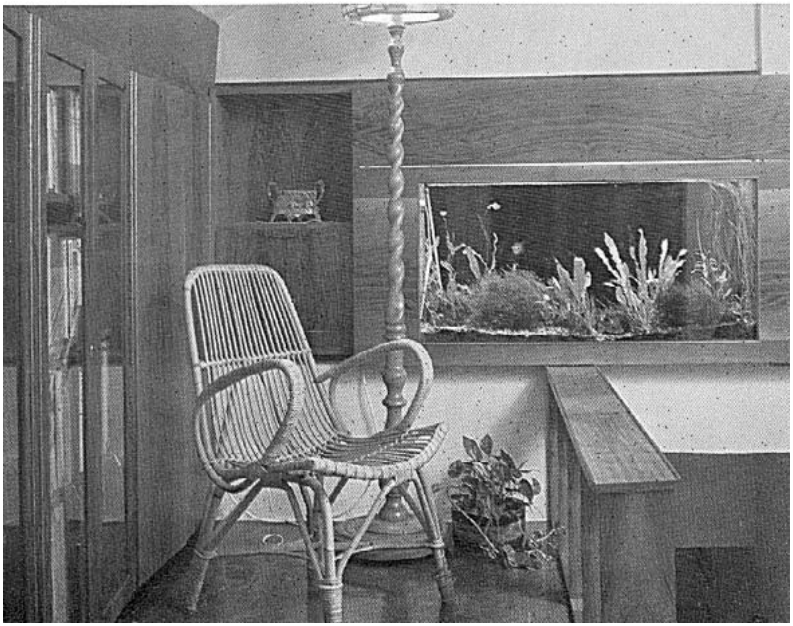
Aquariums planted in this manner require very little maintenance. In order to prevent them from becoming overgrown by algae, a few snails may be added. Water should be added every 2 to 4 weeks to replace that lost through evaporation. These decorative aquariums can be placed in a flower corner with potted plants or separately; potted plants grow very well in the vicinity of aquariums because of the humid atmosphere.

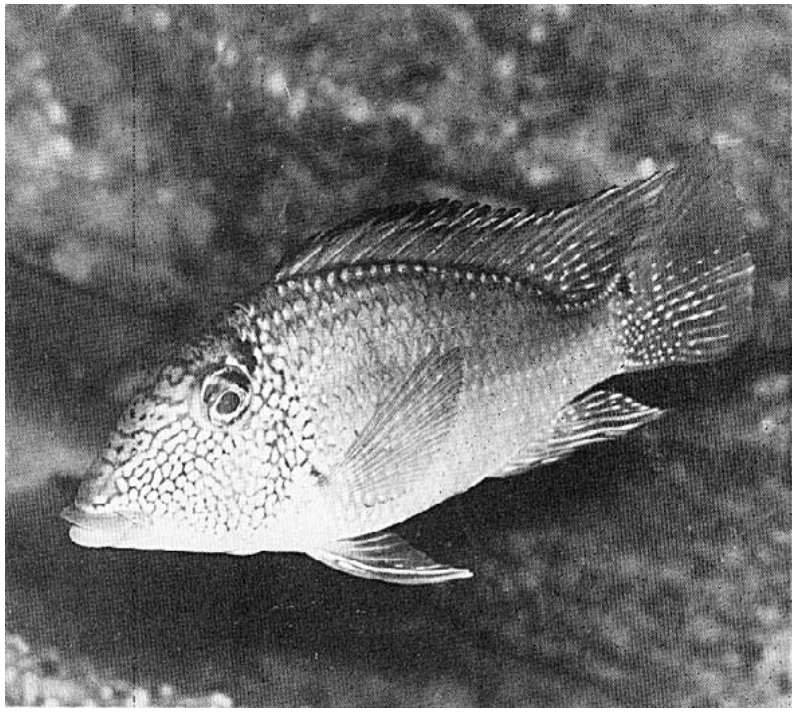
2) An aquarium with fish and plants, serving exclusively as a decoration. This type of tank should meet the same basic conditions as the first type: it should be decorative, increase the humidity, and require little attention. In order for not only the plants but also the fish to be conspicuous, the aquarium should not be planted with any species that grows over-abundantly, because this would mean frequent disturbing of the aquarium in order to thin excess plantlife. Tall plants are not used except for those which do not reproduce vegetatively. This is so the aquarium remains permanently in the condition in which it was first arranged.



The senior author's planted indoor tank complemented by various species of house plants.

Shown is an aquarium installed as an integral part of the wall and room decor. Determining the right position for an aquarium requires some thought and advance planning. Photo by J. Elias.





Geophagus jurupari, a popular aquarium fish from South America, digs in the substrate often in search of food resulting in the uprooting of plants. Photo by H. Hansen.

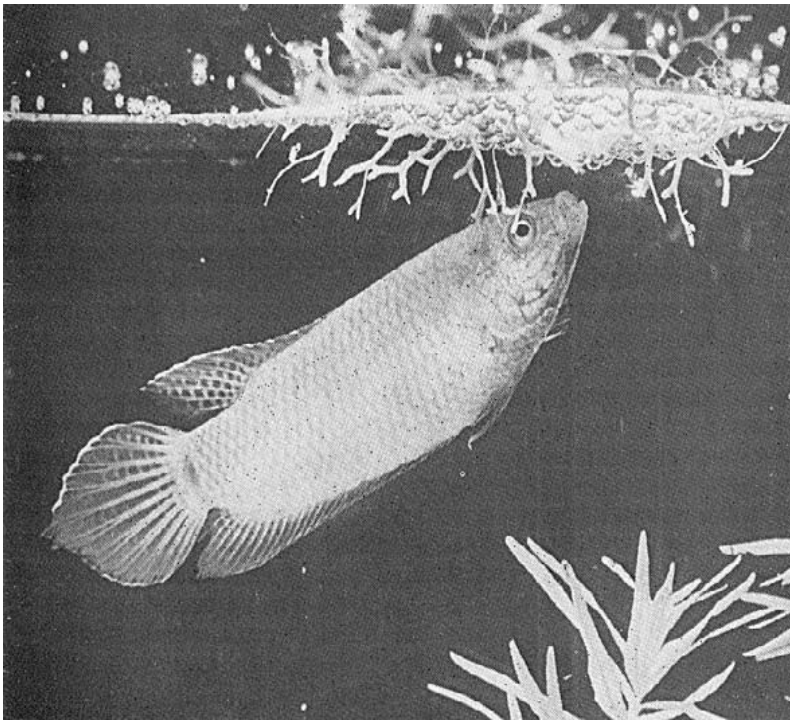
From the first everything is done that will contribute to the stability of the aquarium's appearance. The bottom is arranged in an irregular fashion and a big rock or tree root is placed in the aquarium to create the basic decoration. All stones are allowed to become covered with aquatic mosses, and the tree roots are covered with decorative ferns. The taller plants should be mostly *Aponogeton*, *Echinodorus*, and the larger species of *Anubias* and *Lagenandra*. They may be complemented by the smaller *Cryptocoryne nevillii*, *Sagittaria*, or *Marsilea*. We can also create within the tank a dark, densely overgrown corner with common species of such genera as *Hygrophila* or *Bacopa*. If we want to have greenery just below the surface of the water, use a tuft of *Elodea*, *Heteranthera*, or *Myriophyllum*.

In an aquarium of this type there should be only a few species of fish. *Pterophyllum* (angelfish), *Paracheirodon innesi* (neons),

Brachydanio (danios), and a few pairs of red platies or swordtails are good.

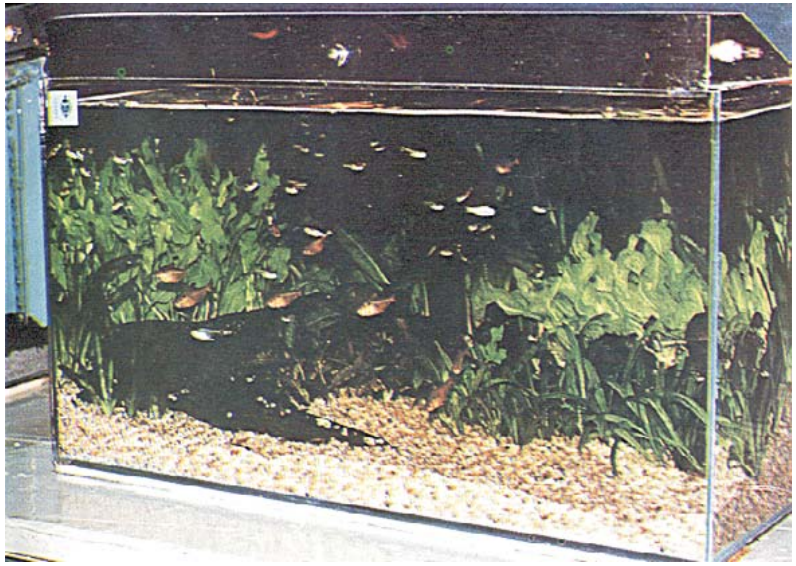
3) An aquarium for the fish specialist. Here the plants are of secondary importance because they are there only to fulfill the relatively minor decorative and biological purposes expected of them. Their maintenance should occupy the time of the aquarist as little as possible. Of the species whose vegetative propagation is rapid, the small plants forming a green lawn over the bottom prove most useful. Of the taller plants, only those that do not reproduce vegetatively (or do so very slowly) can be kept; otherwise they would soon overgrow the aquarium and have to be thinned. Plants must also be chosen that will thrive in the water conditions given to the fish. Thus if mainly tetras are kept, the plants must require or at least tolerate an acid medium (*Cryptocoryne*). If livebearers are the aquarist's main interest, *Echinodorus*, *Sagittaria*,

This male *Macropodus cupanus* has built its bubblenest using some branches of *Riccia*. The plant keeps the nest from breaking up easily.





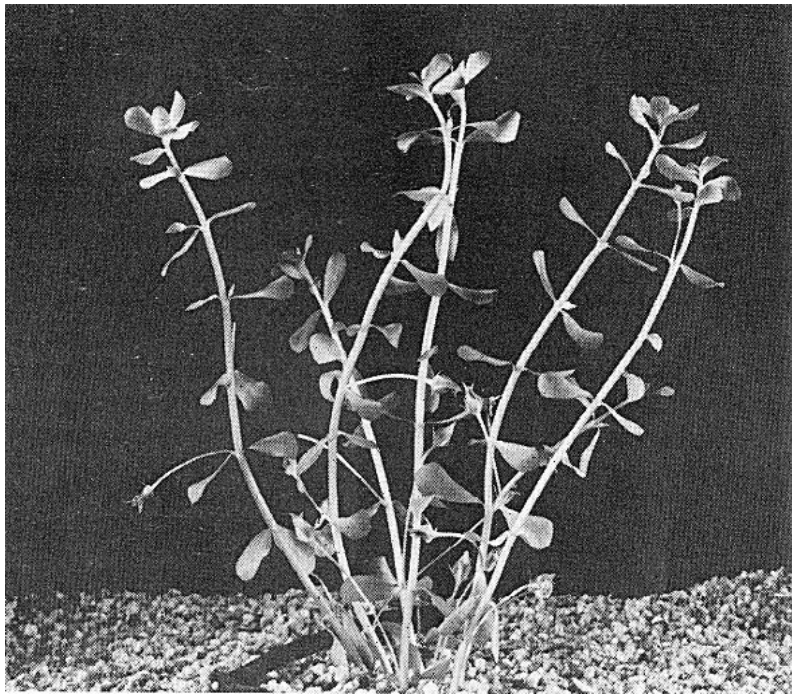
This beautiful display tank with tiger barbs (*Capoeta tetrazona*) is greatly enhanced by the inclusion of actively growing water plants. A good lighting system ensures the growth of the plants. Photo by Dr. D. Terver, Nancy Aquarium, France.



It is also possible to keep plants in a home tank as long as the plants receive the required amount of light and nutrients. Photo by Dr. Herbert R. Axelrod.

Olean water, a rich bottom, and accessibility to sunlight ensure the survival of aquatic plants in this area of Lake Malawi, Africa. Photo by Dr. Herbert R. Axelrod.





Bacopa moniera is one of many aquarium plants cultivated commercially.

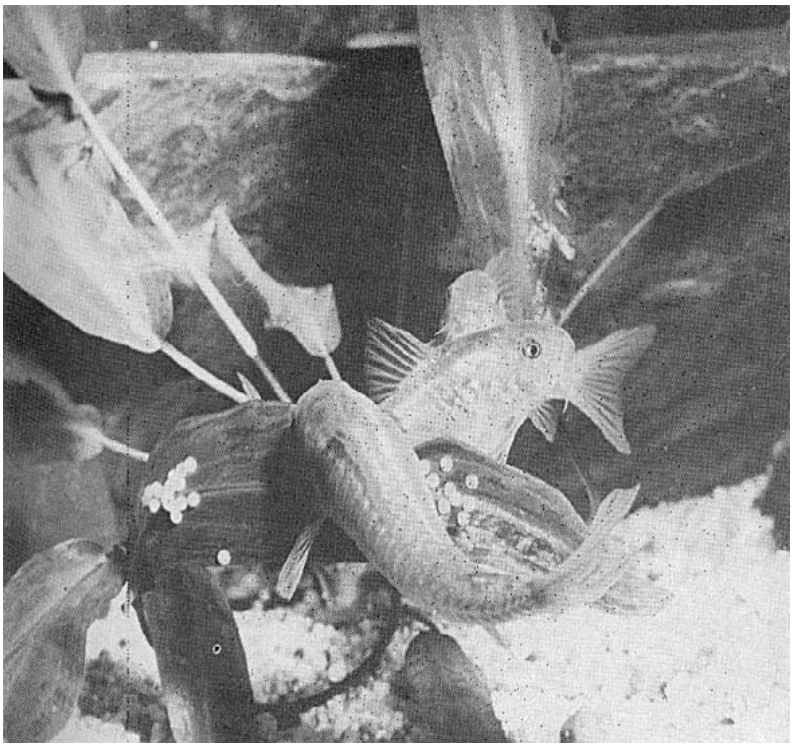
Vallisneria, and *Anacharis* are among the best choices. Mosses do well in tanks with killifishes and are useful in spawning the fish. Cichlids require robust and broad-leaved plants with firm leaves (such as *Echinodorus* and some varieties of *Vallisneria*); the roots of these plants should be protected by stones around the base of the stem so they cannot be dug out by the fish. These and other factors greatly limit the number of really satisfactory plants for each specialized aquarium, and the number is further reduced if the aquarist wishes to keep South American fish with South American plants, African fish with African plants, etc.

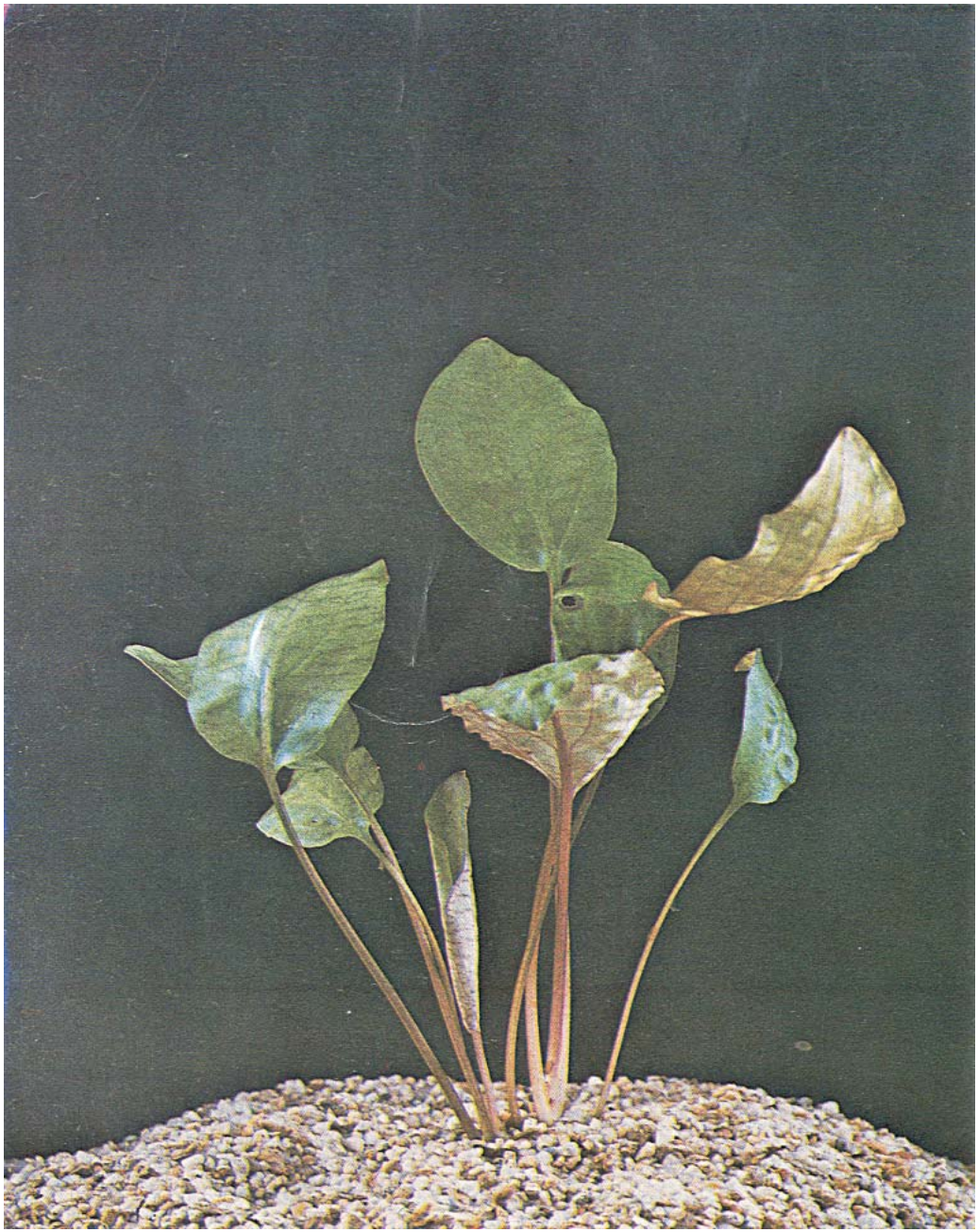
4) An aquarium for the plant specialist. Little can be said about this type of aquarium. The preference is usually confined to certain plant groups (such as *Aponogeton, Echinodorus, Cryptocoryne*, etc.), so the aquarist usually has a fairly good knowledge of the requirements of the plants and how they limit his arrangement of the aquarium. These aquariums are planted with a large number of species and, if the subject matter concerns the species of

a single family, it is always necessary to complement these with other plants of a different structure. Otherwise such an aquarium is certainly valuable but has little decorative effect.

5) Biotic aquariums. These are aquariums which represent as accurately as possible a section of aquatic life in a particular area. The plants are therefore chosen not according to their overall appearance in the aquarium, but strictly on how they fit into the geographic area being reproduced in the tank. The aquarium is planted to resemble a tropical Asian jungle, an African lake, or a lagoon in the Amazon basin of Brazil, among many other possibilities. The esthetic appearance of the finished aquarium must of course be given some consideration. It is also natural that the fish should conform to the area from which the plants were obtained. Some plants typical of the main geographic areas are:

Wide-leaved plants are ideal spawning substrates for armored catfish like *Corydoras aeneus*.





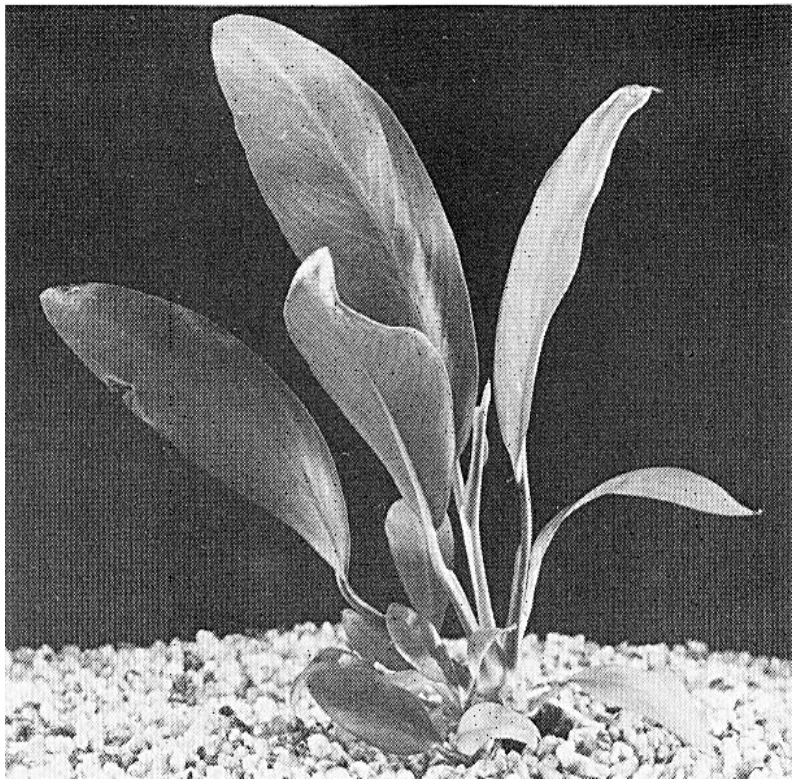
Cryptocoryne siamensis var. *kerri*.



Cryptocoryne axelrodii.

Cryptocoryne affinis.





Anubias congensis is a well known plant from the African continent.

South America: *Echinodorus* (except *E. cordifolius* and *E. berteroi*), *Heteranthera*, *Myriophyllum aquaticum*, *M. elatinoides*, *Alternanthera*, *Hydrocleis*, and *Cabomba*, among others.

Central America: *Bacopa amplexicaulis*, *Cabomba*, *Elodea*, *Ludwigia*, *Echinodorus cordifolius*, *E. berteroi*, *E. tenellus*, *Myriophyllum hippuroides*, *M. pinnatum*, *Sagittaria graminea*, and *S. subulata*.

Africa: here is the smallest choice of plants, and one can mention only *Anubias*, *Lagarosiphon*, *Baldellia*, and *Ranalisma*.

Tropical Asia (including Indonesia): *Cryptocoryne* spp., *Aponogeton natans*, *A. undulatus*, *A. crispus*, *Barclaya*, *Blyxa*, *Hygrophila*, *Lagenandra*, *Limnophila*, and *Vallisneria gigantea*.

Tropical Australia: *Aponogeton elongatus* and *Marsilea brownii*.

7

Algae in the Aquarium

Algae are an ever-present but unnecessary and sometimes dangerous part of the flora of every aquarium. The majority of them are harmful to higher plants because they settle on the leaves and reduce the photosynthetic efficiency of these organs. Some species cover the glass sides of the aquarium and shade the interior; they also prevent the aquarist from observing his fish and plants. The harmless filamentous green algae are also not welcome in the aquarium although they add a natural touch when present in small quantities. Unfortunately they are seldom present in small quantities for long, as they soon cover the bottom from their rapid growth. They can also be dangerous to small fish and fry, which might get stuck in the tangle of filaments and suffocate.

As a general rule, algae are considered weeds in the aquarium as their growth cannot be easily regulated. They are a weed which regularly gets into the water with food, fresh water, new plants, and through the surface with air-borne spores. Each species of alga has definite requirements with respect to the quality of the medium, and it develops only under the correct conditions. The most important of these conditions are temperature, duration and intensity of illumination, the mineral and organic substances in the water and substrate, the species and number of fish inhabiting the aquarium, and the kind and number of pieces of apparatus (such as filters, bubblers, etc.) which effect the movement of the water.

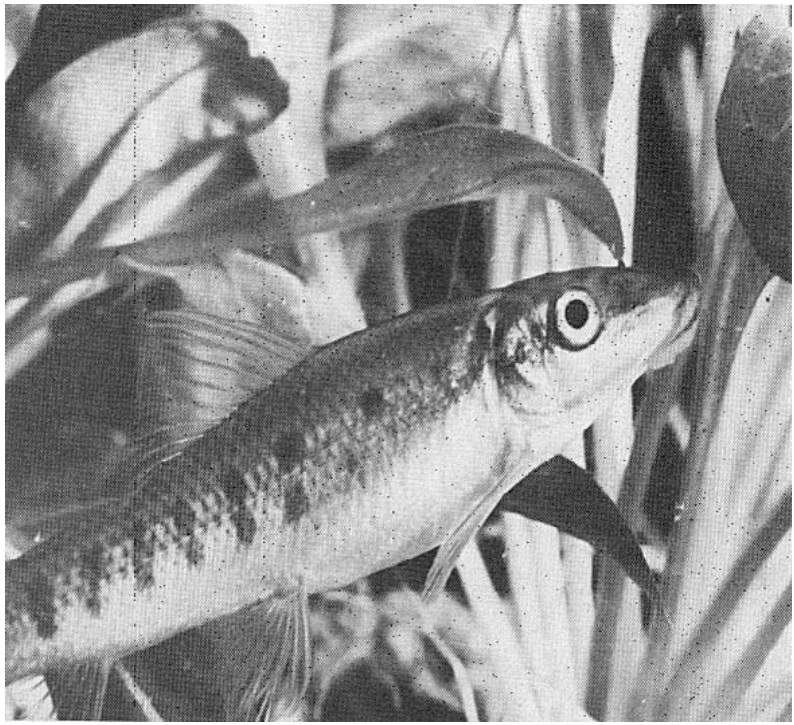
Algae can be fought by removing the causes of development of the specific groups. Generally any species of alga can be destroyed or suppressed by changing the conditions: increasing or decreasing illumination, increasing filtration and aeration, or—most drastic—moving the entire aquarium to a new location. Specific ways of checking individual groups of algae are discussed below. A chemical is now available which will subdue or kill all algae even when used in dosages safe for higher plants and fish in the aquarium. In heavily planted aquariums, however, any chemical can theoretically be dangerous to the plants and should be used with caution.



Algae are responsible for the green color of this standing pool in Indonesia. Photo by Dr. Herbert R. Axelrod.



Newly hatched fry of *Herotilapia multispinosa* find temporary refuge in a clump of vegetation in this spawning tank. Photo by H.J. Richter.



The Chinese algae eater (*Gyrinocheilus aymonieri*) can keep the aquarium walls and plant surfaces free from algae.

GREEN ALGAE (CHLOROPHYTA)

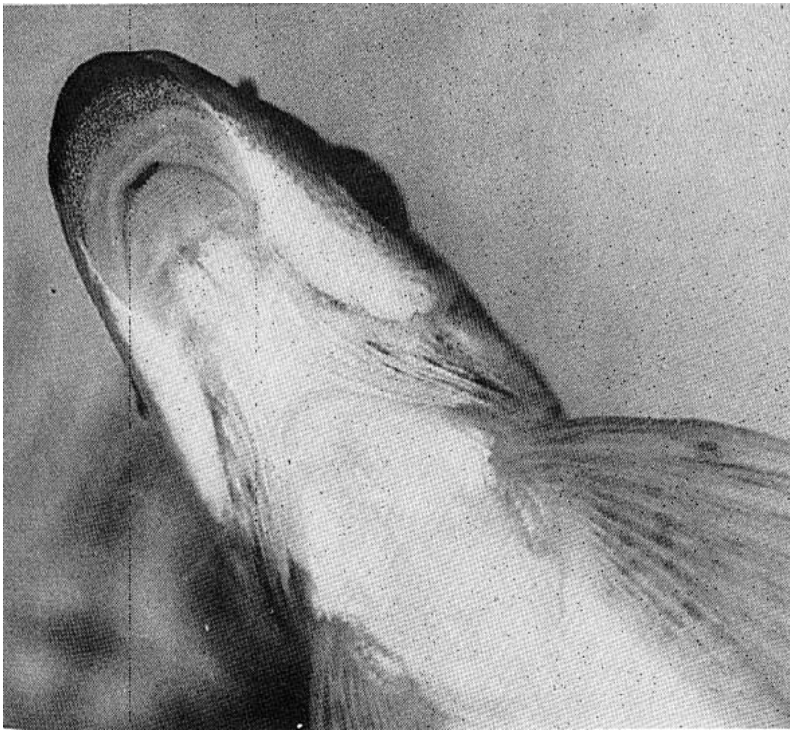
Green algae abound in nature and are distributed all over the earth, although most species are found in freshwater. They reproduce mostly vegetatively but can also develop microscopic sexual organs resulting in minute spores. These spores are easily introduced into the aquarium with water, plants, or through the air.

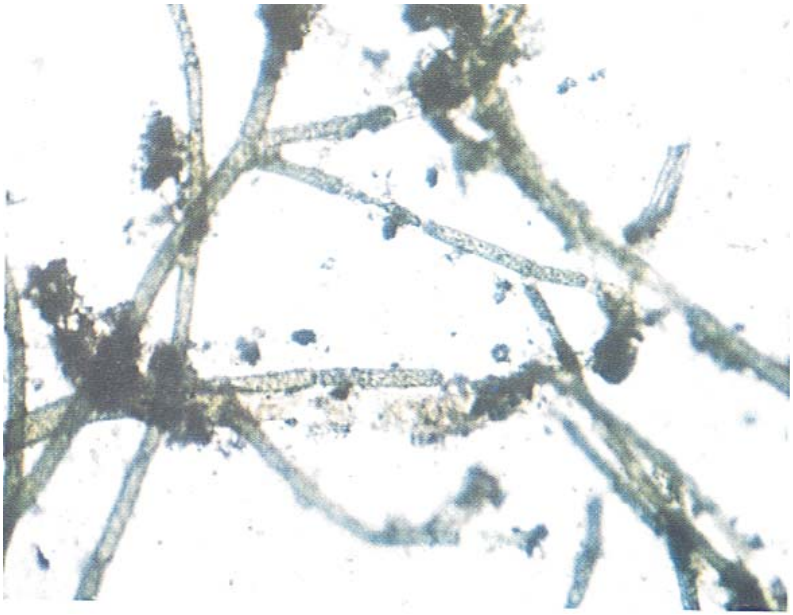
In appearance greens vary greatly from unicellular forms which float freely in the water to multicellular filaments attached to stones or other plants. The unicellular forms may be so abundant as to color the water green or may be attached to plants, the aquarium glass, decorations, and the substrate. The filaments may produce dense tangles among the higher plants. Because their requirements resemble those of many higher plants, they are often common in the aquarium but do little harm unless present in very large numbers. They produce oxygen as well as the higher plants.

The minute species can be very troublesome when they attach to the leaves of plants and decrease their food-making efficiency. They are usually firmly attached and cannot be easily removed. Since they attach mainly to the older leaves and to stems, seldom to young leaves, the infested leaves can be cut off and removed from the aquarium. Algal films on the glass can be removed by various types of aquarium scrapers and sponges.

Filamentous green algae are seldom a nuisance unless they are allowed to reproduce excessively. Unattached filaments should be removed from the aquarium regularly with a net. Most attached filaments are only a few centimeters long and do not interfere with the higher plants. Some look very attractive and can even serve as spawning media for fish.

Ventral view of the Chinese algae eater showing the mouth adapted for scraping off algae.

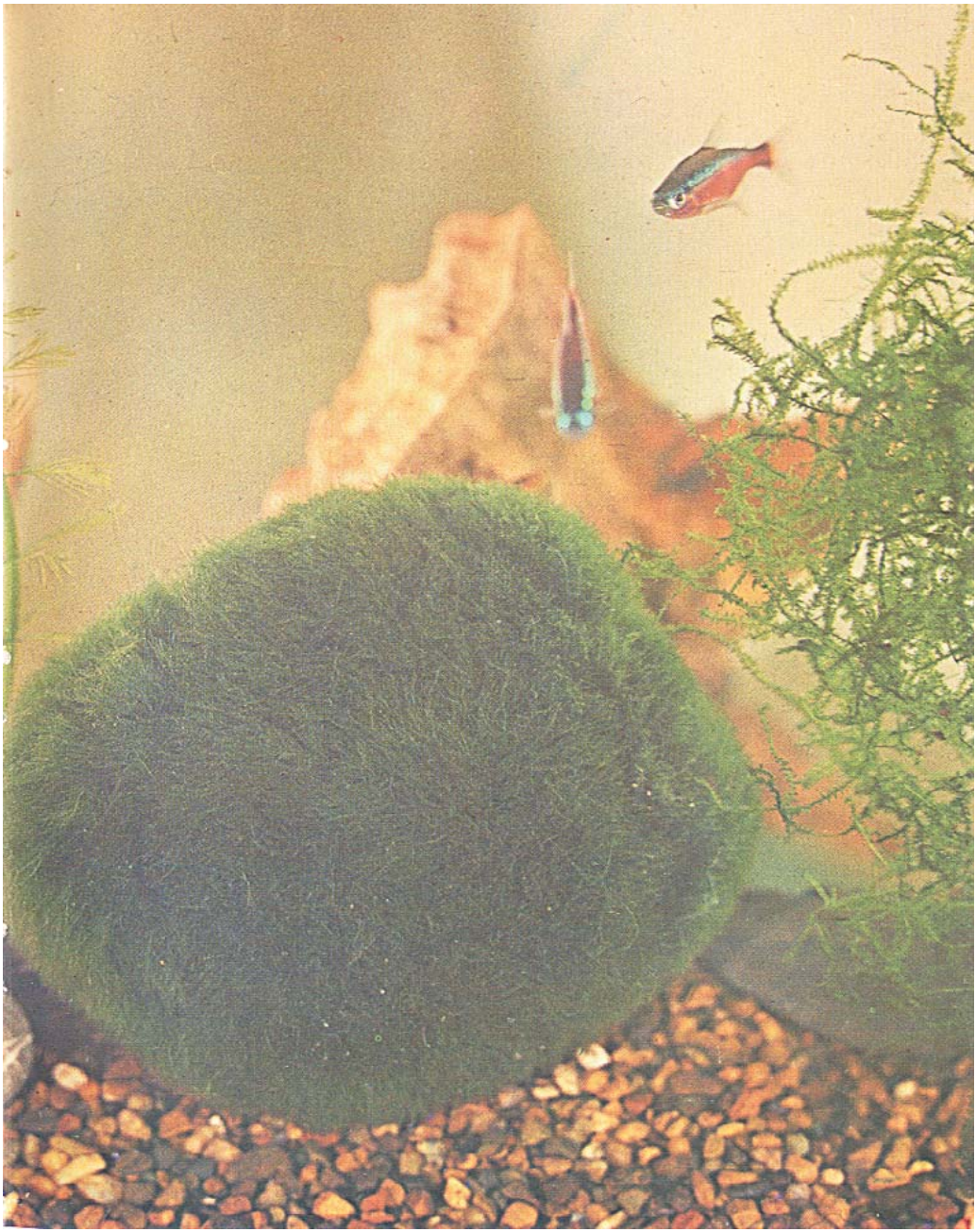




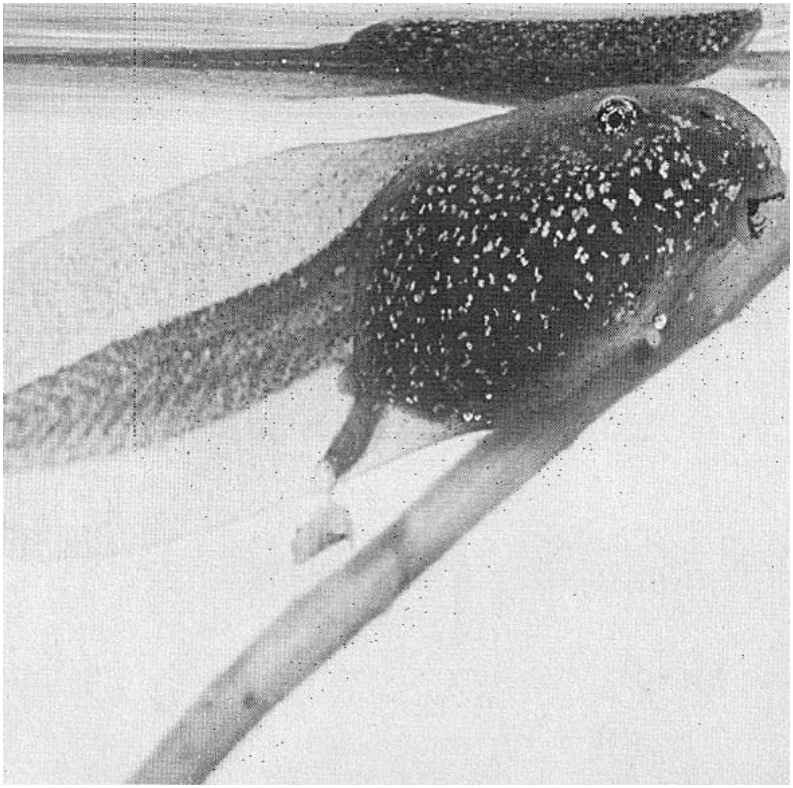
Anabaena sp., a blue-green alga.

Cladophora, a green alga. Photo by Frickhinger.





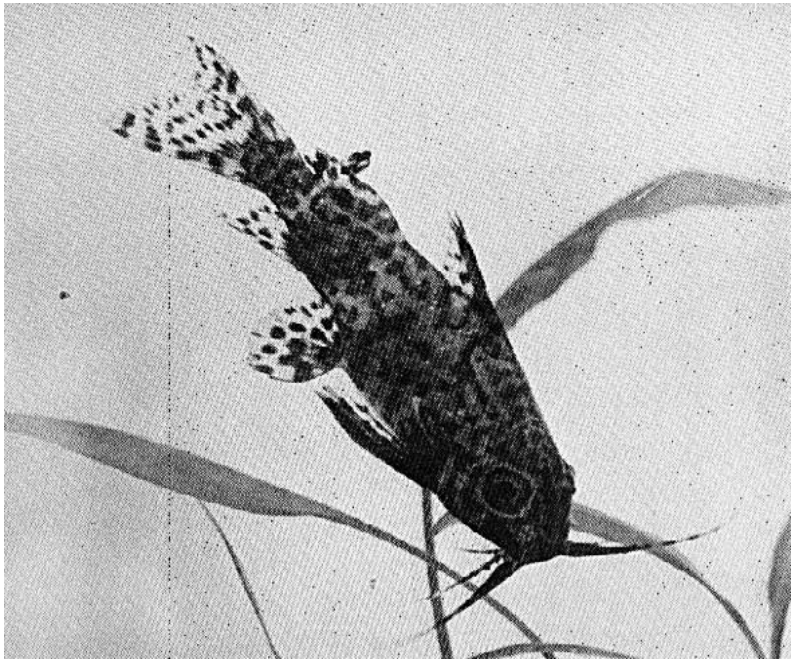
A ball-like clump of *Cladophora* and a pair of cardinal tetras (*Cheirodon axelrodi*). Photo by A. Noznov.



Tadpoles are efficient algae eaters and are easy to obtain. Photo by H. Pfletschinger.

The occurrence of green algae in the aquarium is a sign that conditions are good for the development of higher plants and fish. If kept under control by regular mechanical cleaning of excess algae, they are often a positive addition to the tank. Some species are used as food by such fish as mollies, Chinese algae eaters, many species of barbs, and many of the South American armored catfishes.

Complete removal of green algae from the aquarium is very difficult unless chemicals are used. The fish mentioned above will help, as will snails. Most green algae are too hard for snails, however, which prefer to nibble on the more tender leaves of higher plants.



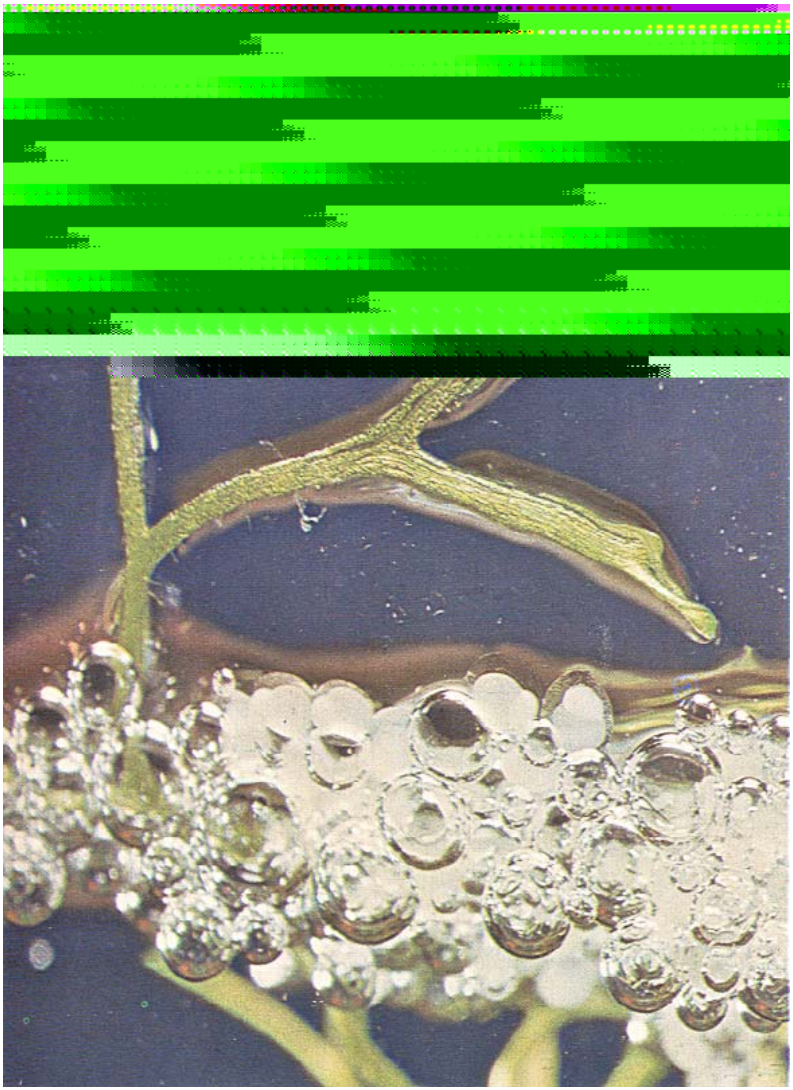
Another well known algae eater is the upside down catfish (*Synodontis nigriventris*). Photo by G.J.M. Timmerman.

BLUE-GREEN ALGAE (CYANOPHYTA)

Blue-greens form a slimy covering of thousands of cells in a gelatinous matrix. This covering not only looks bad and interferes with the leaves of higher plants, but actually smells like a swamp. Fortunately the film is seldom attached and can be removed mechanically from the substrate and plants. These algae are very dangerous in large quantities and could eventually destroy all other life in the aquarium if not controlled. They develop mainly in fresh tap water, especially if it contains a high percentage of calcium salts. They often appear in newly established aquariums or when a large proportion of the water is changed too frequently and is replaced by hard tap water.

Plenty of light and undisturbed conditions are required for the growth of these algae. If the water is in constant motion through heavy aeration or filtration, blue-greens will not thrive; nor will they increase in numbers if there are fish constantly moving through the tank and disturbing the bottom material.

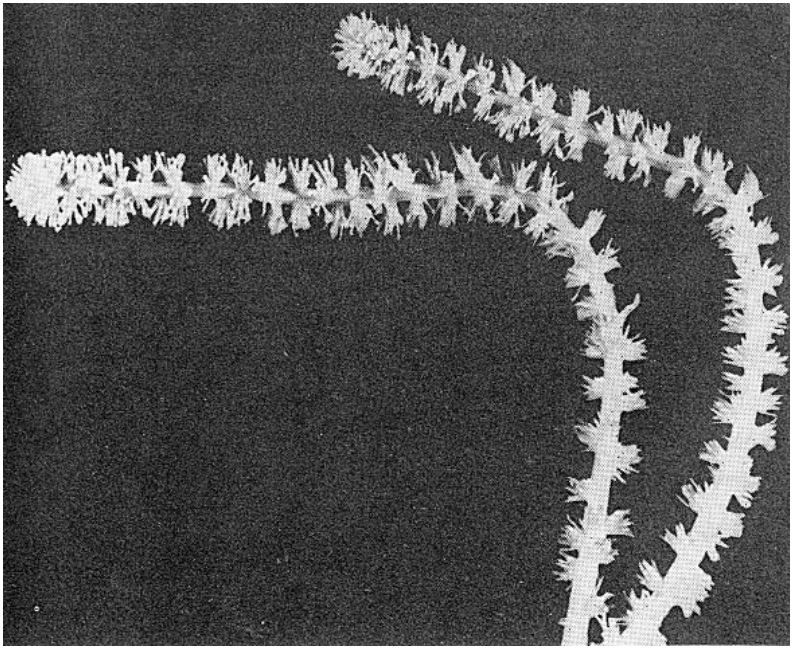


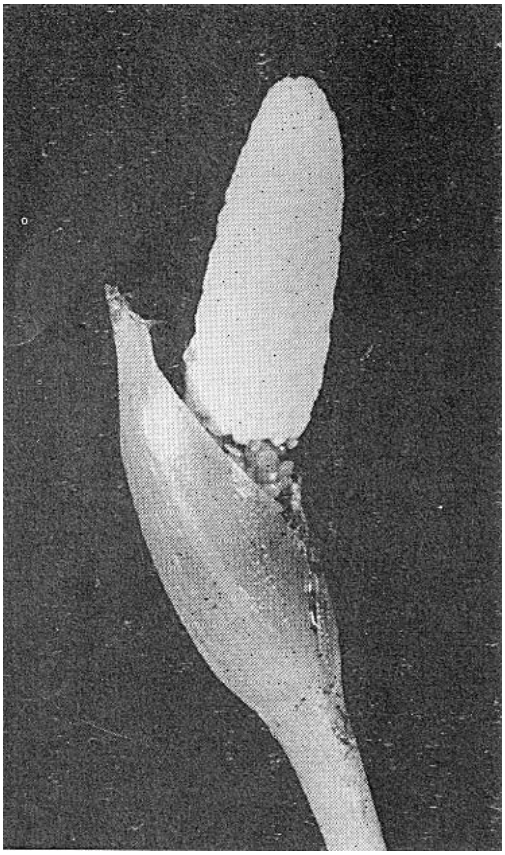


each year after flowering (*Ottelia*), and species such as *Echinodorus cordifolius* which reproduce faster and more abundantly by seed than vegetatively. A few plants, such as *Samolus valerandi*, flower well in terrariums but neither flower nor produce vegetative offspring under aquarium conditions. Such plants are allowed to flower in terrariums or paludariums and the seeds sown underwater or the seedlings transplanted to the aquarium.

In nurseries it is often more practical with such groups as *Echinodorus* to use seeds than vegetative offspring. One year of vegetative propagation might produce 1 to 30 new plants, while a pair of plants during the same time might produce over 1,000 viable seeds. To produce large numbers of new plants vegetatively would require large numbers of parent plants and correspondingly large tanks and floor space, while much less space is necessary for two or three flowering parents and their offspring. Although the plants produced from seeds may take twice as long to reach salable size, the reduced need for space makes generative reproduction economically practical.

Bifurcate spike inflorescence of *Aponogeton ulvaceus*.





Typical inflorescence of *Anubias*. The distal part consists of male flowers only. The female flowers are situated on the more protected basal part.

The major disadvantage of depending on flowering in the aquarium is that many genera and species of aquatic plants never (*Hygrophila polysperma, Najas, Lagarosiphon*) or rarely (*Elodea, Anubias*) flower in the aquarium. Some species flower readily when cultivated emersed, yet flower only sporadically and with special attention in the aquarium, and even then do not produce viable seeds (*Cryptocoryne, Vallisneria*). For these plants we are of course still dependent on vegetative reproduction. In some species succeeding generations produced vegetatively flower more and more rarely or, after developing floral stalks, put out roots instead of flowers. Thus the floral stalk of *Echinodorus osiris* when fully developed produces either buds which never open or root shoots.

ARTIFICIAL POLLINATION

In species where self-sterility predominates, artificial pollination is necessary. Pollen must be transferred by hand from one flower to the stigma of another flower on a separate plant.

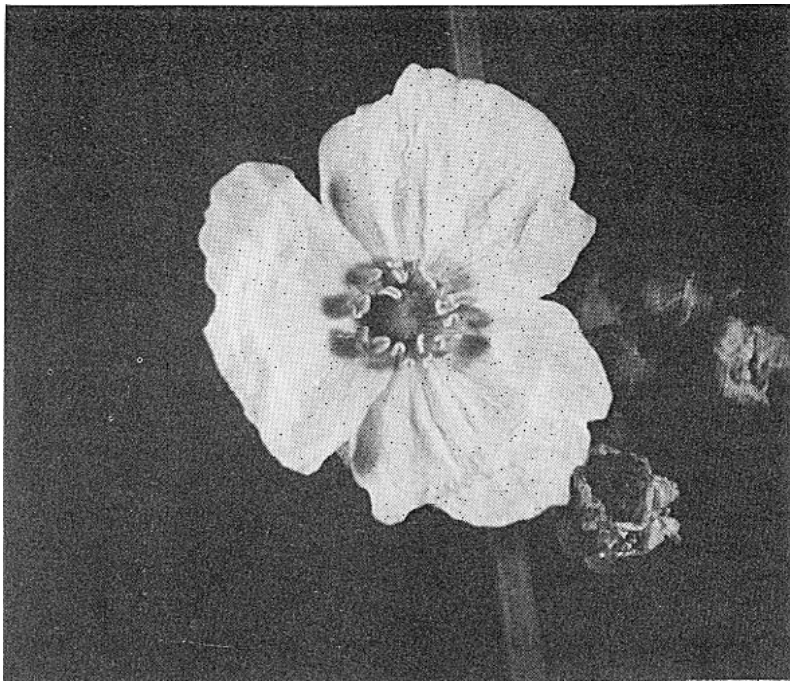
For the best chance of successful pollination, it is wise to fertilize different flowers by transferring pollen from other flowers situated as far away as possible. If possible, flowers from different floral stalks should be used. In *Aponogeton, Echinodorus*, and *Sagittaria* it is common for a single plant to develop 2 or 3 stalks at one time.

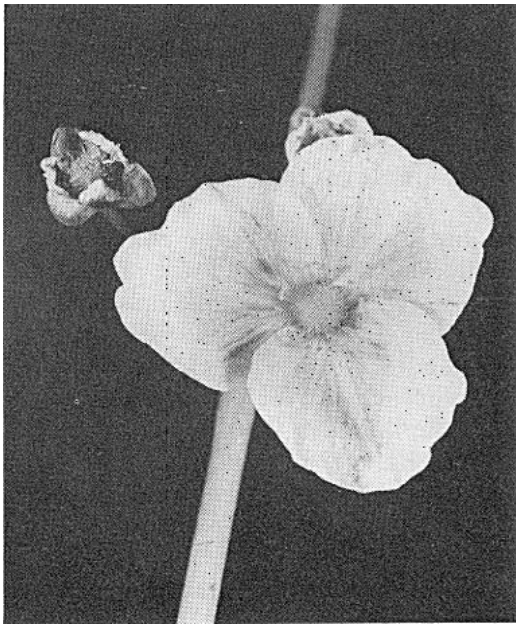
As a practical point it has proved useful to fertilize a flower with a mixture of pollens from both its own species and a different but closely related species. If, for example, the self-sterile *Echinodorus paniculatus* and the self-fertile *E. cordifolius* bloom at the same time, *E. paniculatus* can be pollinated by a mixture of the pollens of both species. This method is used in other branches of horticulture and experiments have shown that by this means seeds of the self-sterile species of *Echinodorus* can be readily obtained. The pollen of another species makes possible the fertilization of flowers by the proper pollen, but no hybrids will develop.

The technique of artificial pollination is not difficult to master. The pollen of one flower is transferred to another by means of a fine brush. In species that produce many flowers pollination can be accomplished by picking flowers and rubbing the mature anthers against the stigmas of other flowers or by shaking off yellowish clouds of pollen into the flowers which are to be fertilized. Pollination should take place in the morning about 10:00 or 11:00, as the pollen is not mature earlier than this and is not loose on the anthers.

We have not yet had any experience with the pollination of some popular species of aquarium plants, such as cryptocorynes, which are undoubtedly self-sterile. The pollen perhaps is transferred in these plants by small insects attracted to the spathes. Perhaps only one species of insect is able to enter the flower and carry pollen, and it has not been imported with the plants. This is also a possible reason why *Vallisneria*, although flowering readily, does not produce seeds in the aquarium.

The *Aponogeton* species are self-fertile, responding to pollen from the same or different plants. The production of seed is heavily dependent on the environment, and the complicated conditions for successful seeding are described fully in the introduction to the family Aponogetonaceae.



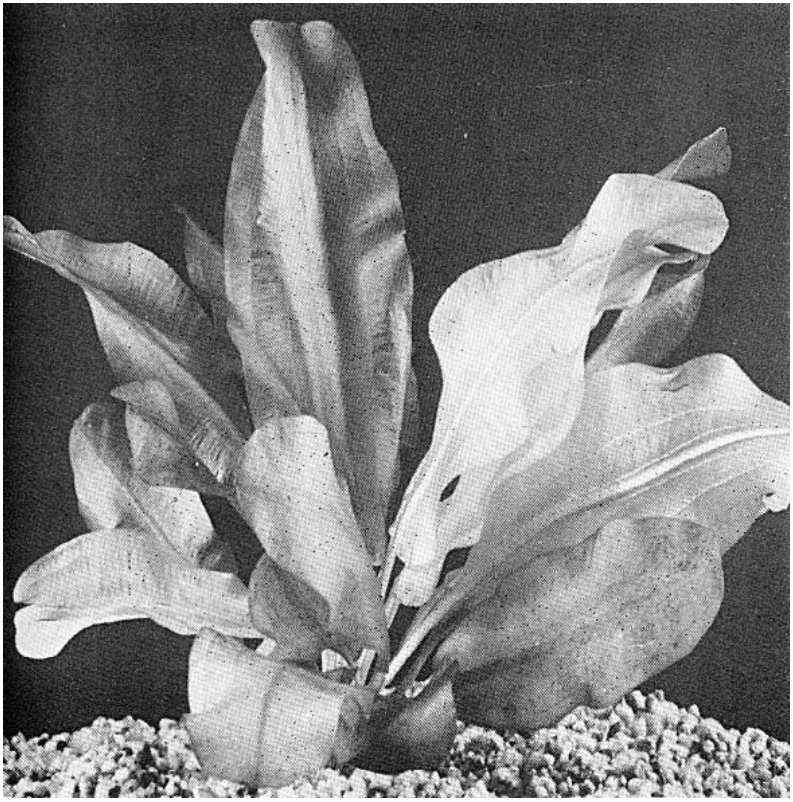


Close-up views of the flowers of the self-sterile *Echinodorus paniculatus* (above) and the self-fertile *Echinodorus cordifolius* (below).

HYBRIDIZATION

Some species of plants can be crossed only with difficulty and the possibility of new forms arising by hybridization is negligible. On the other hand, some plants can be crossed very easily so that large numbers of hybrids have been obtained. New varieties of animals and plants can be obtained either by hybridization, which is often difficult or impossible, or by selectively breeding individuals having wanted traits. Selective breeding of individuals showing unusual traits (usually mutants) has led to many showy varieties of aquarium plants (some *Vallisneria* and decorative forms of *Sagittaria*) and fishes (high- or long-finned guppies and swordtails).

Hybrid formation between known species of *Aponogeton* is not unusual. This unidentified *Aponogeton* species has very wide undulate leaves.



Relatively few successful hybrid plants have found their way into aquariums as yet, but the capacity for hybridization is found in many species of aquarium plants. In nature hybrids between some species of *Echinodorus*, such as *E. cordifolius* and *E. berteroi*, are known. Yet it is not really certain that these are true hybrids, for the possibility remains that they are merely forms or variants of the species. Artificial hybrids of these *Echinodorus* have not yet been created in the aquarium. In *Aponogeton*, however, hybridization is common. It has been proved that the Asiatic *A. crispus, A. echinatus*, and *A. natans* can be easily crossed. Because the subject is rather complicated, it will be treated in detail later.

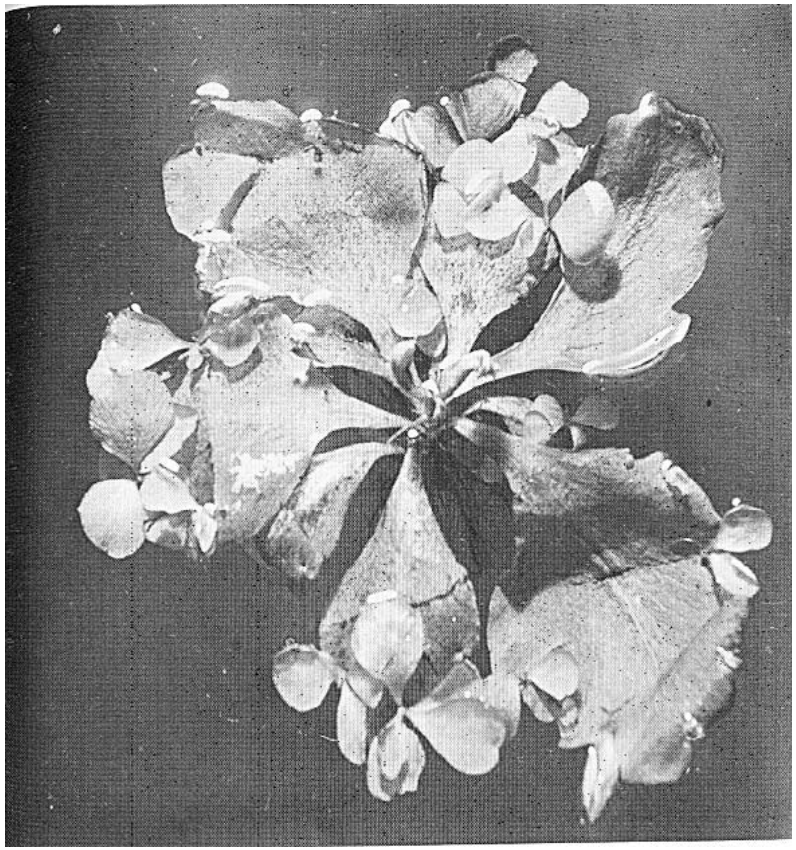
GERMINATION

The seeds of such aquatic plants as *Echinodorus* and *Sagittaria* readily take up water and swell quickly because they do not possess hard and impervious outer coatings. They germinate very readily and quickly. In other genera the seeds are firm and hard, germinating only after a long immersion during which bacteria and other organisms have time to weaken or dissolve the waterproof outer coating. The seeds of *Potamogeton*, for example, require a 'fermentation' process in marshy conditions. In cultivating them, large quantities of seeds are left in small dishes of water where their surface decomposes anaerobically with the emission of foul-smelling gases. Under these conditions many will germinate successfully.

Some aquatic plants develop seeds which germinate immediately after maturing. This group includes the Pontederiaceae such as *Eichhornia* and *Heteranthera*. In other species, perhaps the majority of aquatic plants, the seeds require longer or shorter resting periods of 1 to 6 months between maturing and germinating. During this resting period the seeds can survive both dry and cold conditions.

Fully mature seeds usually are collected from the parent plants in the late summer or autumn and are sown at the beginning of spring or late winter (February or March). The seeds of almost every species of aquatic plant can withstand drying, even when the seeds ripen under water as in *Ottelia*, *Barclaya*, and the like.

If seeds are to be over-wintered they should be dried out properly after collection and then put in paper bags and stored in a dry, well ventilated room. Storing in greenhouses with a high humidity very quickly diminishes their viability. As a general rule,



A floating "islet" of *Ceratopteris* with new plantlets on the margin of the leaf blades. Photo by Dr. D. Sculthorpe.

if the seeds hibernate at average indoor temperatures above 59° F (15° C), they require a very dry medium.

If 'moist' seeds are over-wintered they should be stored at low temperatures, which will inhibit germination. Even a temporary increase of temperature, for instance above 46° F (8° C), may greatly decrease the chances of germination, especially in plants of the genus *Nuphar*. The seeds of *Nuphar* must be stored in cold surroundings, either covered with moss or buried in the sand. When dry seeds are stored, germination is inhibited by lack of moisture; with moist seeds it is by lack of warmth.

At the beginning of spring the seeds of aquatic plants from temperate and subtropical areas are sown at temperatures of 59° to 68° F (15° to 20° C), while those from the tropics are sown at temperatures of 77° to 86° F (25° to 30° C).

The seeds of typically submersed plants (*Ottelia, Barclaya, Nuphar*) are sown in water about 10 cm deep. Amphibious species are sown on the surface of moist sand; only after the seeds have germinated and the first roots have appeared are they covered by a layer of water 12 to 25 mm deep. This is suitable for *Bacopa, Limnophila, Myriophyllum, Sagittaria*, and some species of the genus *Echinodorus*.

Many plants are provided with only moist sand in their dishes even after germination and are not covered with water (and then only a few centimeters) until the seedlings reach a height of 50 to 90 mm. This procedure is followed in the case of the majority of *Echinodorus* species, such as *E. cordifolius, E. macrophyllus, E. paniculatus, E. tenellus*, and others, while it is the only suitable way of ensuring a high yield of such genera and species as *Samolus valerandi, Ammania, Ludwigia*, and *Hygrophila*.

Aponogetons are the only plants commonly transplanted after germination. The mature seeds are left in soft water (rain water is best) at temperatures around 54° to 59° F (12° to 15° C) for a period of 1 to 2 months. Then the temperature is raised to about 77° F (25° C) and the seeds are left to germinate. The seedlings, 25 to 40 mm high and with well developed leaves and roots, are then planted in sand on the bottom of a shallow, well lit aquarium and the water level is gradually raised. The seeds of the true species (not hybrids) of *Aponogeton* are left in cool water, usually for the whole winter and until the spring (which in nurseries and greenhouses may begin as early as late February).

VEGETATIVE PROPAGATION

This is the most common method of propagation used by aquarium hobbyists and is also used at the commercial level. Some species of aquatic plants are commonly reproduced by rhizome runners (*Cryptocoryne, Vallisneria*) or by root runners (*Sagittaria*). In *Echinodorus* this is relatively rare and is found only in the smallest species, *E. quadricostatus* and *E. tenellus*. Vegetative reproduction in *Echinodorus* is most commonly through the development of new plants on the floral stalk, where rooting plantlets arise in the axil of the flower petioles. The same process is found in the "viviparous" species of *Aponogeton*.

Numerous species of aquatic plants can be propagated by cuttings or by fragments of the plant body that can take root and continue growing. This is common in plants of the genera *Ludwigia*, *Elodea*, *Ammania*, *Alternanthera*, and many others which sprout new branches from the axillary buds at each separate internode of the stem. In some plants this ability is so strongly developed that even torn leaves or their fragments may take root, as in *Hygrophila polysperma* and *Bacopa amplexicaulis*.

A further source of vegetative reproduction lies in the rhizomes of numerous species. If they are separated from the parent plant, new plants will develop from the dormant buds on them and become separated in the course of time. This is most useful in plants with a cylindrical rhizome that is long and creeping, such as *Anubias*, *Acorus*, and some *Echinodorus* (*E. osiris*).

In perennial plants without the typical cylindrical rhizome new plants will develop around the perimeter of a globular woody rhizome if it has been plucked out of the sand and left underwater in the light. This method is useful with *Echinodorus berteroi*, among others.

The rhizomes of some perennial plants can also be divided into 2 to 6 parts, each of which is able to continue growing independently. This is possible with most of the plants in the family Araceae, with *Aponogeton* species, and with all larger species of *Echinodorus*. In some perennial water plants the rhizome cannot be divided, for either the plant is entirely destroyed or only a single part of the divided rhizome will grow, that on which the single growing point has remained. *Nuphar* and *Nymphaea* are this way.

Since with few exceptions vegetative reproduction does not require any special professional knowledge and often occurs spontaneously without intervention of the aquarist, the few problems encountered occasionally will be discussed only with the descriptions of the exceptional species.

10

Characteristics of Tropical Floral Areas

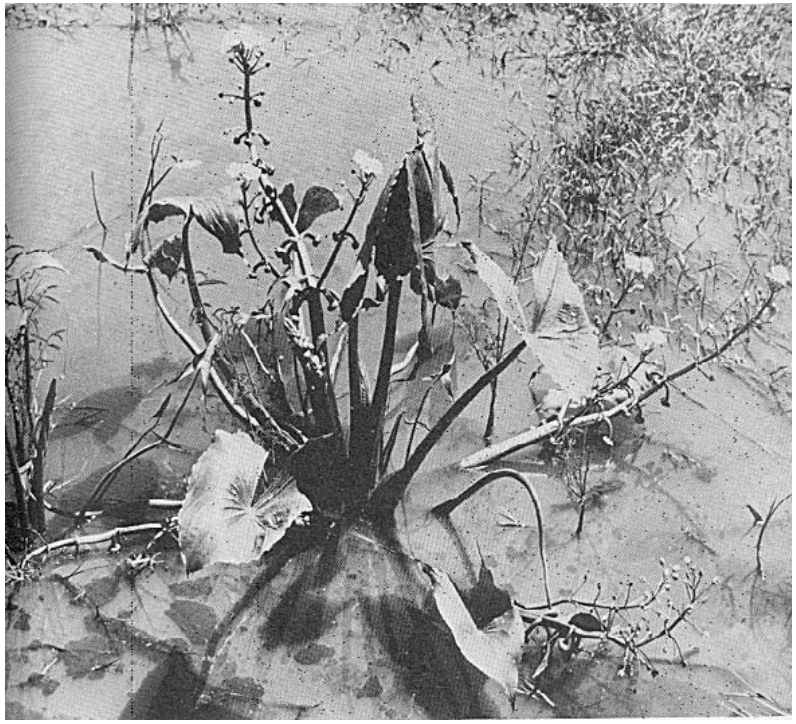
Conditions for the growth of water plants vary considerably in different parts of the world. For this reason it is useful to describe briefly the principal ecology of the aquatic and marsh vegetation in the more interesting parts of the world from the aquarist's viewpoint: the tropics of Asia and South America.

THE TROPICS OF SOUTH AMERICA

The Amazon basin, measuring over 2½ million sq. mi., is for the most part a great plain, especially in the middle and lower reaches of the river. The South American forests, to which we turn because of an interest in *Echinodorus* species, do not have marshy characteristics but resemble temporary water reservoirs. It is true that the deep forests are moist, but they are entirely without permanent standing water. Where any great water surfaces are found, they are mainly concentrated in the vicinity of large rivers which during the rainy period overflow their banks and inundate the surrounding countryside. After the water has drained back into the main stream, a system of still backwaters and pools arises, often very extensive, which during the dry period gradually changes into marsh or dries out entirely.

There are two rainy periods in this area (January to April and November to December). Between these two periods there is a dry stage which is not so conspicuous as it is in the areas where there is only one rainy period and where, consequently, the dry period is longer.

Rainfall in the Amazon area reaches 20 to 25 meters a year, and it tends to rain more often in the upstream direction. As everywhere in the tropics, the rainfall is distributed unevenly so that during the rainy period the daily downpours cause floods. At this



This photo shows the typical marshy conditions of the natural habitat of *Sagittaria montevidensis* in the Amazon. Photo by H. Schulz.

time the water level of the Amazon rises by anything up to 15 meters (on the average, 3 to 6 meters) and the force of the flooding river destroys the vegetation. Only a few plants grow successfully year after year either in the river or on its immediate banks. In the vicinity of the river no trees grow and an open landscape arises, with the result that fluctuations of temperature during the day and over the course of the year are much greater than, for instance, in the jungles of southern Asia. In the main stream of the river only a very small number of annual species grow, and these are propagated by seeds or spores (examples are *Victoria*, the giant water-lily, *Pistia*, water lettuce, and *Azolla*, a fern).

Plant communities in the vicinity of the Amazon arise in accordance with the undulations of the terrain. In the lowest-lying places, which are flooded at any slight rise in the water level, no trees grow. During the rainy period the whole area is inundated



Note the scarcity of vegetation in this almost dry marshy terrain near Rio Araguaia, Brazil. Photo by Dr. H.R. Axelrod.

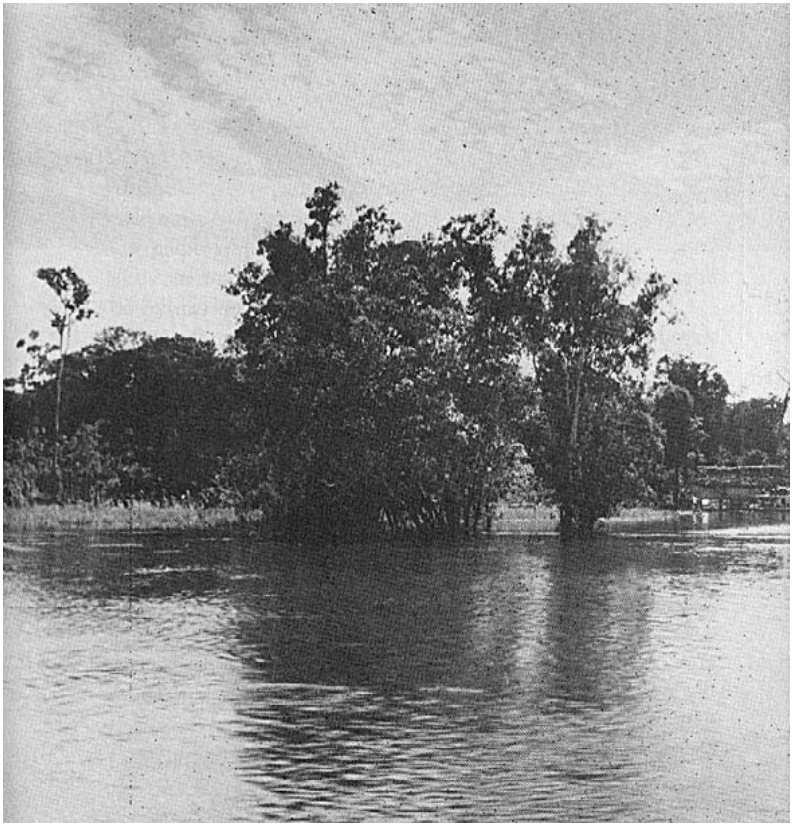
and later (during the dry period) becomes muddy and quite impassable. Yet even here annual plants prevail to grow and during the short dry period produce seeds. Perennial plants do badly at this level and seldom survive to produce seeds.

From the point of view of the aquarist, the most interesting habitats are situated 6 to 9 meters above the normal level of the river and are flooded only during the highest waters of the rainy

season. After the waters recede, extensive lagoons and marshes are formed as the ground gradually dries out. These provide suitable habitats for the amphibious species of *Echinodorus*. In the lagoons where the water remains all year, both amphibious and typically submersed plants are found, such as *Echinodorus amazonicus*, *Cabomba*, *Heteranthera*, *Myriophyllum*, and others.

The average annual temperature of the Amazon area is 77° to 79° F (25° to 26° C), but during the year the temperatures may vary from 57° F to as much as 104° F (14° to 40° C). The fluctuation in temperature is therefore considerable, explaining why the South American species of aquatic plants are generally very resis-

A river bank scene along the Rio Negro, a tributary of the Amazon River. Note the low vegetation in the background of the picture. Such vegetation is under water during the rainy season. Photo by Dr. H.R. Axelrod.



tant to temperature changes, the majority of them able to be cultivated successfully even in unheated indoor aquariums. The temperature of the river water in the Amazon basin varies from 65° to 86° F (18° to 30° C) in quiet areas of still water. It reaches an average of 83° to 86° F (28° to 30° C) in lagoons during the vegetative (dry) period, but during unusually warm periods shallow lagoons can reach as high as 104° F (40° C).

In the tropics of the Amazon we find variable habitat conditions that produce what is sometimes called a cycle of development in plants. During the rainy period there is a stage of inconspicuous vegetative rest caused by the mechanical effects of fast moving water and movement of soil driven by flood waters. In addition there is a lowered temperature and a lack of light because the muddy water transmits little sunlight. When the floods are over the submersed plants start to flower; with the development of leaves such plants as *Echinodorus* also sprout flower stalks reaching above the water surface or, as in *Cabomba,* develop both floating leaves and flowers. Amphibious plants develop leaves now but do not yet flower.

By the time the water level falls to 20 to 40 cm most submersed plants have finished flowering and the floral stalks of some types begin to take root after maturing. A period of vegetative propagation follows. On the contrary, amphibious species develop only floriferous stalks. This means that in one and the same place various kinds of plants grow in stages, one after the other, also flowering in sequence, a definite cycle of development.

Other changes in the composition of vegetation can be observed on the fringes of lagoons and still waters where the treeless formations of the savannas pass into marshes and on to the shallows of the river. Here the development of the plants is extraordinarily varied. The specific composition of the plant growth varies continually, the number of some species is increased, and others disappear temporarily or permanently. The plants very often change their shape and the size of their leaves (the so-called "leaf multiformity"). On the fringes of the waters, on the banks and in the shallows, are found such plants as *Echinodorus quadricostatus*, *E. tenellus*, and various species of *Eleocharis*. Toward the savanna zone are found various marsh plants of the Araceae family which are not capable of withstanding permanent inundation. Toward the lagoons, even in shallow water, plants of the genera *Myriophyllum* and *Heteranthera* grow, while everywhere on the surface of both shallow and deep still waters are many floating plants.



This picture illustrates the variety and density of vegetation in the backwaters of Rio Negro, Brazil. Photo by Dr. H.R. Axelrod.

The aquatic and marsh plants of the Amazon area are thus characterized by a relatively great ability to withstand fluctuations of temperature. They tolerate ordinary indoor conditions and are not damaged by even a fall of temperature to 54° or 59° F (12° or 15° C). The species are mainly amphibious and can be cultivated in both paludariums and aquariums. Distinctly submersed plants are very rare, and even these can grow emersed for a short time (*Heteranthera*, *Cabomba*). The South American plants of the genus *Myriophyllum* are better adapted to an emergent life than are species from all other continents except Australia.

The aquatic and marsh plants of tropical South America have no distinct resting period, growth ceasing only during those floods in which their leaves and more delicate stems are destroyed. That

is why they can grow indoors all the year around and are content with a temperature of about 68° F (20° C). Illumination for about 12 hours a day suits them well at all seasons. Of the conditions in their environment, it is the depth of the water that mainly influences their development. Since they are characterized by a high resistance to external conditions, the South American plants are most suitable for the aquarium. In indoor aquariums we can prepare much better and more stable conditions than are offered in their natural habitat.

It should not be forgotten that a number of very decorative aquarium plants from South America do not grow in the tropical area proper, but in the subtropical and temperate zones of southern Brazil, Paraguay, Uruguay, and Argentina. Here are found the exquisite novelties of our aquariums, such as *Echinodorus osiris, E. horemanii, E. opacus, E. longiscapus,* and many others. These species, growing permanently under water, are found in relatively cool conditions with temperatures about 58° to 67° F (14° to 19° C). This of course does not mean that they could not do well at the ordinary aquarium temperature of about 72° F (22° C).

THE TROPICS OF THE INDO-MALAYAN AREA

Together with the South American tropics, this area produces more aquarium plants than any other area. Most aquarium plants (and fish) from the Indo-Malayan area originate from the Malayan peninsula and Indonesia (especially the larger islands of Java and Sumatra), Borneo, the Celebes, and New Guinea. A great number of species also come from Ceylon (Sri Lanka).

The most conspicuous feature of the area is the absence of large rivers. In the places where, because of thorough drainage, no rice fields have been cleared, the whole country is covered with impenetrable jungle interspaced with small lakes, rivers, and marshes. Two factors, the land being covered by dense vegetation plus the proximity of the sea, influence the nearly constant temperature which varies only slightly from 77° to 81° F (25° to 27° C). During the changing seasons of the year as well as during the day, the temperature varies so slightly that an almost constant annual temperature may be said to reach a substantially higher value than the temperature of tropical aquariums in the home.

The greater part of the Indo-Malayan area is very rainy (25 to 40 meters rainfall per year). Though the rains are distributed over two periods, no distinct dry period occurs (except in the eastern



A typical rural scene in Thailand. In this kind of habitat the environmental conditions do not change very much throughout the year. Photo by Dr. H.R. Axelrod.

part of Indonesia), so the waters have no periodic variations in conditions and in the jungle there are many permanent water reservoirs of large and small size. Only in very shallow pools and in marsh formations does the depth of water vary sufficiently to be able to influence the composition of both aquatic and amphibious vegetation.

The flooding in this tropical area is not caused simply by rising river waters, but during the rainy periods an excess of water is present everywhere and increases evenly. Afterward the height of the water level decreases evenly. The aquatic vegetation is therefore not damaged by a wild current and the cycle of development is distinct in the numerous species of amphibious plants.

Although a great number of species of water plants come from the Indo-Malayan area, the most typical of them are the Araceae, particularly the cryptocorynes. The typically submersed species (*Cryptocoryne affinis*, *C. siamensis*, *C. cordata*, etc.) grow in



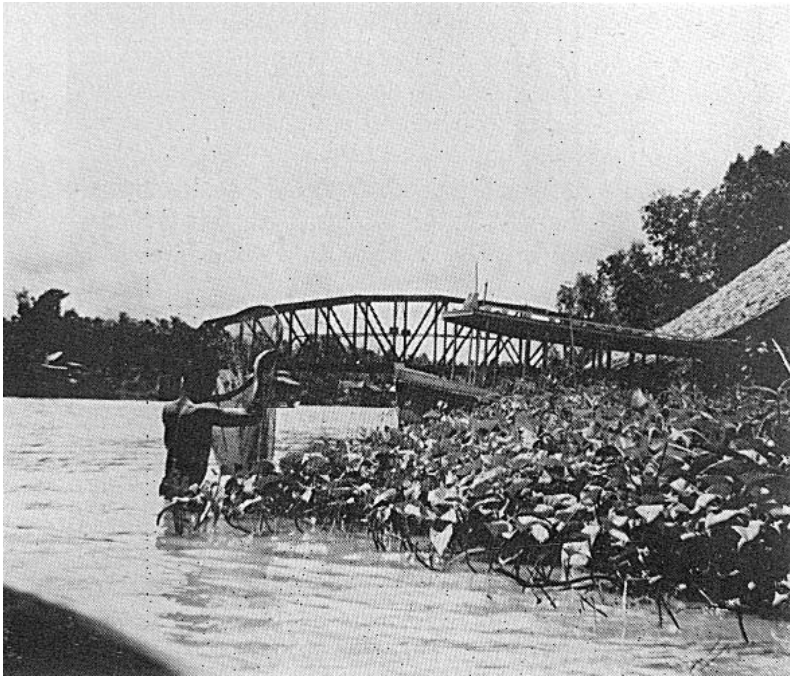
A typical site in a rubber plantation in Indo-Malaysia where *Cryptocoryne cordata* is found growing in the irrigation canals.

permanent, often very deep, waters and can flower throughout the year, although in waters deeper than 30 to 40 cm they do not flower but are propagated vegetatively. In such cases the cycle of development is not typical.

Amphibious species (*C. becketii, C. walkeri, C. nevillii, C. lucens*) are submersed during the rainy period, when there is a stage of vegetative propagation by runners from the rhizome. If the water level falls they pass into the emersed way of life, when they flower and produce seeds. These species are typically plants of the jungle formations. They grow in semi-shaded conditions under several layers of luxuriant forest growth, often in water where the surface is quite covered with floating plants.

Other aquatic Indo-Malayan plants such as *Limnophila, Ceratopteris*, and *Bacopa* are found in artificial and natural channels which connect the lagoons and small lakes.

In summary, the Indo-Malayan species of plants are characterized by a medium which offers them an unvarying and relatively high temperature, about 79° to 83° F (26° to 28° C), for both air and water. The aquatic vegetation consists of amphibious spe-



A mass of amphibious vegetation growing along a river bank in Bangkok, Thailand. These plants are rarely completely inundated except, perhaps, during extreme high water as a result of a typhoon. Photo by Dr. H.R. Axelrod.

cies (*Lagenandra*, some *Cryptocoryne* species, *Limnophila*) as well as typically submersed species (some *Cryptocoryne* species, *Myriophyllum*). They have no period of vegetative rest, but some amphibious species, in accordance with the period, are capable of vegetative growth and propagation as well as a flowering stage with the consequent production of seeds.

The plants of this area are, therefore, more exacting in their requirements. They are sensitive to fluctuation in temperature, especially to serious drops which for extraordinarily delicate species may be deadly even at 65° F (18° C). Other plants may succumb at about 59° F (15° C). It is essential to give Indo-Malayan plants temperatures of 77° to 80° F (25° to 27° C) throughout the year.

Some cryptocorynes can be induced to flower only with great difficulty. Even though a sufficient number of experiments has not

yet been undertaken along this line, it can be presumed that in artificial cultures it is necessary to adhere to the normal cycle of development if blossoming is to be encouraged: the change from emersed to submersed growth and back again must be duplicated by a regular fluctuation of the water level.

According to notes on herbarium sheets and detailed observations by Prof. Schulze (1967 and 1971), aquatic plants in the Indo-Malayan area (particularly *Cryptocoryne*) grow within three main biotopes.

1) Banks of strong rivers up to 10 to 100 km from the mouth. The cryptocorynes grow in well lit or only slightly shaded areas up to 50 meters above sea level. Under these conditions are found all the species preferring the terrestrial way of life. They are nearly always found in shallow waters, the leaves and inflorescences growing above the level of the water, as in the case of *C. ciliata*. These species are often found along strong streams penetrating deep into the woods, but wider streams may have more vegetation on their banks because of increased illumination. These species do not grow in association with *Lagenandra* and *Hygrophila* because they do not occur in river beds. Other species of the genus *Cryptocoryne* also are not found in river beds with such a biotope. The aquatic vegetation is represented chiefly by *Aponogeton rigidifolius, Myriophyllum* spp., *Hydrilla verticillata, Blyxa*, and *Potamogeton* species. The submersed form of *Crinum thaianum* joins this typically Malayan flora in Thailand. In Sarawak *C. ciliata* occurs with *C. lingua* and *C. pontederiifolia* var. *sarawacensis*; these species often descend right into the beds of rivers together with *Barclaya mottleyi*. In spite of the nearness to the sea, *C. ciliata* grows mostly in the areas with fresh water. It is rarely found in areas with brackish water.

2) Small streams up to 2 to 10 meters wide and under normal circumstances quite shallow (10 to 30 cm), with the surface rising to 1 or 2 meters after heavy rains. These brooks are found in thickly wooded and shaded areas, usually in elevations of 50 to 100 meters in Ceylon (rarely to 500 meters) and 1200 meters in northeastern India. The main characteristic of these biotopes is crystal clear water with a pH of about 6 to 6.5, and mainly soft rainwater. The bed of the brooks is rocky or stony and covered with a sand-silt mixture brought down by running water from higher elevations. The cryptocorynes occur mainly in cultures of single species on overgrown river beds and are exposed to the conditions of amphibious life. Depending on the rainfall, the depth of the water often



A newly collected *Cryptocoryne* plant from its natural habitat in Thailand. Photo by Dr. H.R. Axelrod.

varies within a few days from 1 to 2 meters to a few centimeters. In such conditions *C. balansae* grows in Thailand, *C. wendtii* and *C. axelrodii* in Ceylon, and *C. bullosa* in Sarawak. In the case of lowland species living at 25 to 100 meters above sea level, *C. nevillii* and *C. becketii* ascend to the limit of 500 meters in Ceylon, and *C. crispatula* was found up to the height of 1200 meters in northeastern India.

3) Marshes of primeval forests, tidal mangroves, irrigation canals of rubber plantations, and stagnant waters. The beds of these localities are usually soft, either muddy or of sandy clay. The water is crystal clear and slow moving, usually neutral or a little acid. Only during rainfall are these areas flooded with thick layers of mud and the water becomes tinted brown, which temporarily lowers the pH. *Cryptocoryne cordata* as well as *C. lingua, C. gracilis*, and other species grow mainly under these conditions.

Plants in nature are exposed to some environmental conditions which can be duplicated in the aquarium only with difficulty. An aquarium is only a small water reservoir into which only a few plant species can be planted. These species may come from diverse

parts of the world and are quite unrelated to each other. Yet the dissimilarity of plants in natural locations is nullified by the fact that there is the same depth of water all year, and usually also the same temperature and other physical and chemical conditions. As a rule only the duration and intensity of the light vary.

In the aquarium other changing conditions appear, conditions that are unknown in nature. In nature the least variable part of the habitat is the soil, while in the aquarium it is very variable. If the bottom is enriched with organic substances (peat, humus, etc.) they will influence the composition of the water and may themselves undergo anaerobic decomposition. Consequently poisonous gases arise to adversely affect the medium. Thus the advantage of using clean sand which is gradually enriched from normal decomposition of plant and animal wastes.

In natural aquatic plant communities there is generally a characteristic biological balance. In accordance with the depth of the water, the temperature, illumination, etc., some species develop only in certain seasons of the year, later to die and give place to others. The species composition therefore changes with the period of vegetative growth and the period of flowering. This does not occur in the aquarium.

The main reason for the disturbance of the biological balance is the fact that conditions in the aquarium change but little during the year. The community is not subject to the proper cycle of development, but the species for which the conditions of a certain aquarium are most favorable thrive to the detriment of plants not so favored. The species which propagate vegetatively repress the plants propagated only by seeds. In darker aquariums the members of the genus *Cryptocoryne* will prevail and make the growth of *Echinodorus* and *Vallisneria* impossible; in lighter aquariums the reverse occurs.

The interaction between the separate species of plants is therefore much stronger in the aquarium than in nature. After a while it is generally necessary to make certain changes in the aquarium such as thinning out the overly abundant species, removing shade plants, and regulating the amount of floating vegetation.

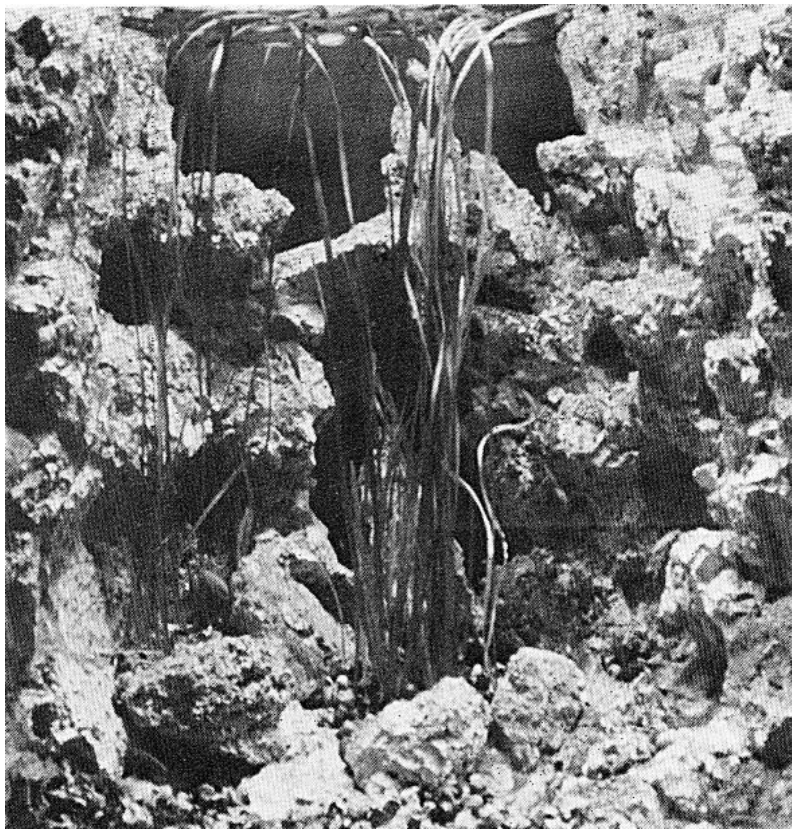
The facts that the amount of water in the aquarium is relatively small and that changes take place (although slowly) mean that various species of plant influence each other chemically by acting upon the properties of the water. For example, *Cryptocoryne* species tend to acidify water while *Vallisneria* species tend to alkalize it. This causes a mutual intolerance between some spe-



Enormous amounts of silt from surrounding higher ground account for the brown color of this tributary of the Amazon River at Tefe, Brazil. Photo by Dr. Herbert R. Axelrod.

A great mass of water plants growing under water in the very clear waters of the Paranajuba River, Upper Xingu, Brazil. Photo by Harald Schultz.





Vallisneria is best maintained with those plant species that tolerate alkaline conditions. It can also be utilized alone as seen in this set-up. Photo by Dr. Herbert R. Axelrod.

cies of aquarium plants, which sometimes becomes much more evident in the aquarium than in nature.

It goes without saying that this intolerance does not arise where the aquarium is planted with a greater number of species. It may, however, appear in those aquariums where *Cryptocoryne* plus *Vallisneria* or *Cryptocoryne* plus *Sagittaria* combinations form a substantial part of the vegetation. In darker aquariums the growth of *Cryptocoryne* species will predominate, which will influence the reaction of the water because they will acidify it and thereby further inhibit the development of the *Sagittaria* or *Vallisneria*, eventually arresting their growth. In brightly lighted

aquariums there are better initial conditions for the development of the latter two genera, which will regulate the reaction of the water toward the neutral point or will alkalize it slightly, inhibiting any further development of cryptocorynes.

In summary, we have seen that the aquarium is mainly a sector of shallow to moderately deep bankside waters and cannot support the diverse forms of vegetation that are present in various depths and on bankside fringes in nature. Thus it is ideal to complement an indoor aquarium with appropriate containers of various sizes in which shallows covered with floating vegetation can be maintained and where a number of marsh and amphibious flowering and non-flowering plants can be cultivated.

In this aquarium set-up the tall and more robust plants are confined to the background, while the low vegetation is limited to the front part. The bushy-leaved plants provide some contrast to the broad-leaved forms.





Terrestrial plants (trees) and aquatic plants (floating and emersed) are seen growing together in this area of the Amazon River at Tefe, Brazil. Photo by Dr. Herbert R. Axelrod.



Glossadelphus zollengeri is an aquatic moss from Java and Celebes. The small black and white photo shows a part of the plant in detail. Photo by Dr. D. Terver.

11

AQUATIC AND AMPHIBIOUS PLANTS SUITABLE FOR THE AQUARIUM

Non-Flowering Plants (Cryptogams)

Cryptogams are non-flowering plants that are not capable of forming seeds and are propagated by microscopic spores. Such spores seldom develop in aquariums, so these plants are propagated vegetatively. The Bryophyta (mosses and liverworts) and Pteridophyta (ferns) belong to this primitive group of plants.

HEPATICEAE (Leafy Liverworts)

Liverworts are minute green plants that can be propagated by spores enclosed in pods, but they are usually propagated vegetatively. Most liverworts live in moist places and in water.

RICCIACEAE (Thallose Liverworts)

This is a family of minute liverworts with a flat thallus. The thallus is the undifferentiated body of these plants, in this group disc-shaped or stellate in form. They live for the most part on moist soil, but some have adapted entirely to life in the water, where they float on the surface or live submersed, attached to other plants or to the bottom.

RICCIA (FLOATING LIVERWORT) (Ill. 53)

The thallus is lobate and forked, with the ventral surface finely scaled. Altogether there are four similar species known from the tropics and the temperate zones.

RICCIA FLUITANS L. (Ill. 104)

R. fluitans is probably a cosmopolitan species. The thallus is ribbon-shaped (with 2-5 prongs), 15 mm long and up to 1 mm wide. This widely distributed species is found on the surface of backwaters and ponds. It develops submersed as well as floating and terrestrial forms. Submersed forms are usually disc-shaped, light green, and attached to the ground or in tangles of underwater plants. Floating forms are very varied in shape; under optimal conditions a conspicuously grassy green globular form develops. Land forms with developed roots appear on disturbed moist ground and on banksides.

This species is not exacting with respect to light and soil composition, but disappears in tanks with a high nutrient content. It is a good spawning medium, but it is necessary to inhibit its growth, which can be abundant. In the aquarium it hibernates regularly.

RICCIOCARPUS

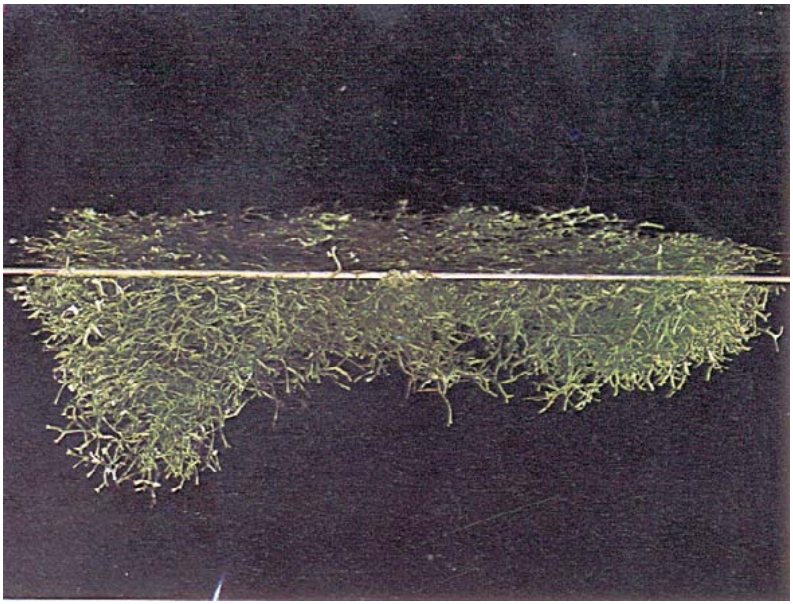
This genus is represented by a single species, *Ricciocarpus natans* (L.) Corda, which is distributed almost throughout the globe. The cordate thallus is an ashy gray-green, 5 to 15 cm long, and 5 to 10 mm wide. On the lower surface of the thallus purple ribbon-like scales can be seen against the brownish purple background.

Ricciocarpus natans is a very decorative species which grows on the surface of peaty pools, ponds, and still backwaters. It is found as both a fully-floating form or as a land form. A winter resting stage is less common in this species than in *R. fluitans*.

MUSCI (Mosses)

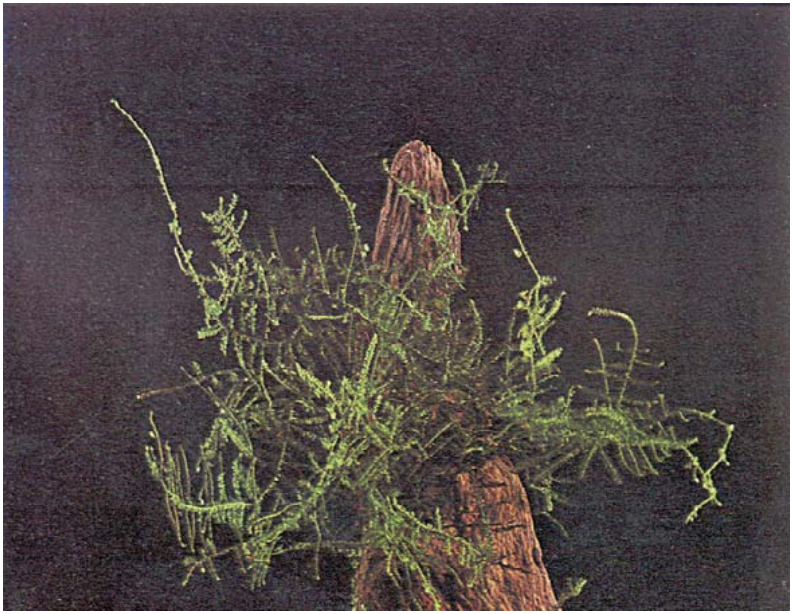
Mosses are minute plants living in the most varied places, from dry rock to water. These plants propagate by spores. Very little attention has been paid to mosses in aquariums and terrariums. In spite of importation difficulties, a great number of amphibious

* **In order to facilitate the location of illustrations, each apropos reference has been noted alongside the homologous description, in small type. Thus, for example, "Ill. 75" means "See page 75 for an illustration of this plant."**



Riccia fluitans.

Vesicularia dubyana.





Salvinia minima.

Isoetes malinverniana.



and aquatic species do quite well as very decorative additions to the list of aquarium plants. There are many beautiful forms for both terrariums and aquariums. They grow like curtains of fine leafy lace which, combined with carpets of other plants, can add a strange charm to the tanks. Only those examples that are known to do well in aquariums are treated here.

VESICULARIA DUBYANA (C. Mull.) Broth (Ill. 104)

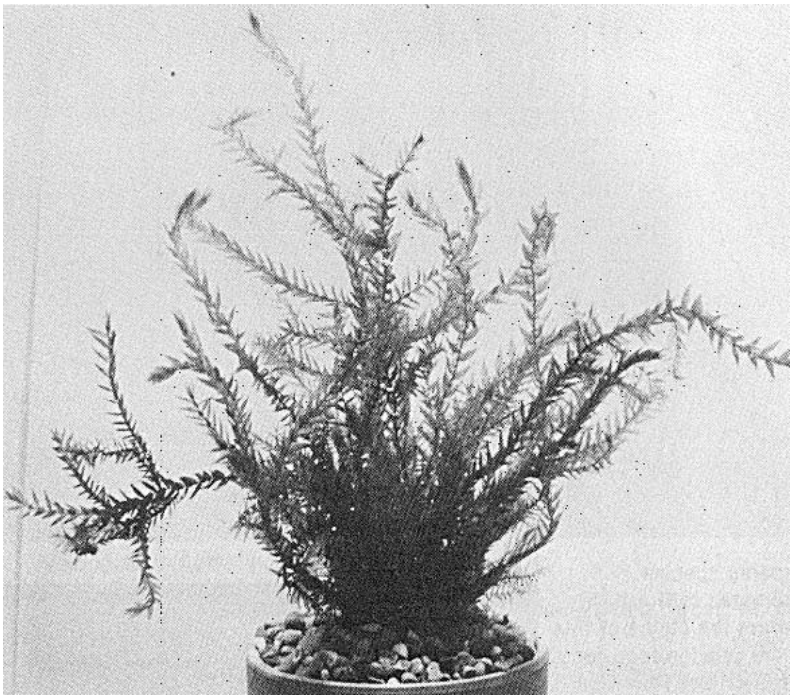
This plant belongs to the family Hypnaceae (of the 30 genera only the genus *Vesicularia* contains aquatic representatives). There are about 135 *Vesicularia* species coming from the warmer regions of the world, with a few species from Southeast Asia and Africa submersed plants. Only *V. dubyana* is frequently cultivated as a decorative aquarium plant.

In its original home, tropical Southeast Asia, it grows amphibiously in moist jungles, covering fallen trees, stones, or the soil. The small stems are irregularly branched, with the leaves arranged in two rows. The lanceolate emerald green leaves are 10 to 15 mm long and 5 to 7 mm wide. In land forms they are wider and a glossy dark green or sometimes olive yellow-green.

In the aquarium *V. dubyana* is cultivated in rather shady conditions attached to stones and other objects. It requires soft, clear water and temperatures about 68° to 77° F (20° to 25° C). Initially it grows very slowly, but once attached it grows faster and spreads over rocks or other decorations, increasing the natural look of the aquarium. It blooms even under water. In paludariums *V. dubyana* grows more rapidly than when fully submersed, covering the surface of stumps, branches, and stones with a beautiful green carpet.

DREPANOCLADUS ADUNCUS (Hedw.) Moenkem

D. aduncus belongs to the family Amblystegiaceae, which contains about 16 genera with aquatic members. This plant occurs in temperate to cold climates, but it is exceptionally adaptable and able to withstand temperatures from 10° to 28° C. In nature it often appears in masses in moist places and in water. Typically amphibious, it occurs in rivers and peat bogs from the lowlands up to the mountains in Europe, Asia, North America, and New Zealand. Like *V. dubyana* it extends over stones and submersed wood, forming a green or yellow-green to brownish cover of plants. *D. aduncus* can be used successfully even as a spawning plant and is able to exist in very hard water. Light conditions are not critical; the plant does not die even during long periods of darkness or in



Fontinalis antipyretica. Photo by Dr. D. Sculthorpe.

high temperatures of spawning tanks and also winters well.

In spite of all these features we prefer *V. dubyana* for the tropical aquarium. With *Drepanocladus* it is possible that your success as a grower will depend very much on the geographical origin of the plants.

FONTINALIS (Ill. 107)

Fontinalis belongs to the family Fontinalaceae, which comprises water mosses with floating and rooted forms. They grow in running streams as well as in stagnant water of ponds, backwaters, and wells. The firm glossy green water mosses with ovate to lanceolate leaves belong to the genus *Fontinalis*. These plants rarely produce spores but propagate vegetatively. The family has 3 genera: *Fontinalis*, *Brachelyma*, and *Dichelyma*, but only *Fontinalis antipyretica* is commonly cultivated in aquariums.

This species is distributed throughout Europe, northern Asia, North America, and northern Africa. The leaves on the stem and branches are trihedral ovately lanceolate.



Isoetes species collected in Brazil. In nature the stems of this plant provide food for water birds. Photo by T.J. Horeman.



Close-up view of *Salvinia auriculata*. Photo by T.J. Horeman.



Regnellidium diphyllum. Photo by T.J. Horeman.

Dense clumps of *Salvinia auriculata* in Brazil growing like a carpet. Photo by T.J. Horeman.



In the running water of clear brooks and small rivers the plant grows attached to stones or develops submersed to amphibious forms; in stagnant waters it becomes attached to the substrate. In lakes the rooted forms may appear at a depth of 2 to 3 meters. As a land form it appears only temporarily, for in the summer it dries out quickly. It has been found that in acid water *Fontinalis* develops short but densely leaved forms, has normal growth in a neutral medium, and in alkaline water has branches which are elongated but with very minute leaflets.

In the aquarium *F. antipyretica* requires a rather cool temperature (68° F, 20° C), slightly acid to neutral water, a sand or gravel base, and somewhat shaded tanks. Smaller plants are best placed in tanks together with the stones on which they are growing. Larger examples are found in stagnant waters. As a decorative species it is suitable in either form and can be used for spawning.

PTERIDOPHYTA (Ferns)

Pteridophytes are vascular cryptogams propagated partly vegetatively and partly by spores which are dispersed by wind or water. The technique of propagation by spores is lengthy and requires considerable knowledge. For this reason aquatic ferns are generally propagated vegetatively either by dividing the rhizomes and stems or by separating new plantlets developing directly on the leaves of parent plants.

ISOETACEAE (Quillwort Family)

This family contains two genera and is represented by perennial plants living either submersed or amphibiously (the latter is especially the case with the species from the Mediterranean area). There are also species with land forms that live on wet soils. The subterranean rhizome is generally short, the narrow leaves forming a dense rosette. The lower surface of the leaf is usually ovate and the upper surface is awl-shaped. Roots are fibrillar and branched.

ISOETES (Ill. 108)

The genus *Isoetes* has about 75 species distributed in the warm areas of the northern hemisphere. Only a small number of species are found in the southern temperate zone or in the tropics. Water birds and rodents like to eat the stems of *Isoetes*.

Sterile plants can be determined only with difficulty. Some plants of this genus are imported occasionally for aquariums, but

identification is difficult or impossible. Most often they belong to the following species.

ISOETES LACUSTRIS L.

I. lacustris is found in Europe, Siberia, and North America. The rhizome is 20 to 30 mm long, globular; leaves are dark green, stiff, cylindrical in cross section, 8 to 28 cm long, and 8 to 30 mm in diameter.

It grows in clear water with a sandy substrate, mainly in lakes (rarely in ponds) at a depth of 30 cm to 3 meters. When the water is silted or frequently disturbed, it disappears quickly.

In spite of growing in cold lakes in nature, *I. lacustris* does well in temperatures above 68° F (20° C). It requires soft water and some shade. The plant is propagated by dividing older tufts or by spores; growth is very slow.

ISOETES ECHINOSPORA Durieu

This slow-growing species from Europe differs from *I. lacustris* by its thicker rhizome (10 cm long) and fine, short-pointed leaves. Both species grow under the same conditions in nature. It requires very cool water and soon dies in aquariums.

ISOETES MALINVERNIANA Cesti et de Notaris (Ill. 105)

The habitat of this species is the Po River basin in Italy, where it grows in local brooks. It is the largest of European species, has light green leaves 30 cm to 1 meter long and 1 to 2.2 mm thick.

This is a well known species in the aquarium, requiring water with temperatures from 68° to 77° F (20° to 25° C) and reasonably deep tanks where its size can be best displayed. It can be propagated not only vegetatively but also by spores sown in the sand where, with sufficient heat and moisture, they germinate readily. When the plants are about 10 mm high they are transplanted and set out at intervals of about 30 mm. Before reaching a height of about 10 cm they are replanted several times; later they can be transplanted into a tank. Great care and attention should be given during transplantation as the plants are very fragile.

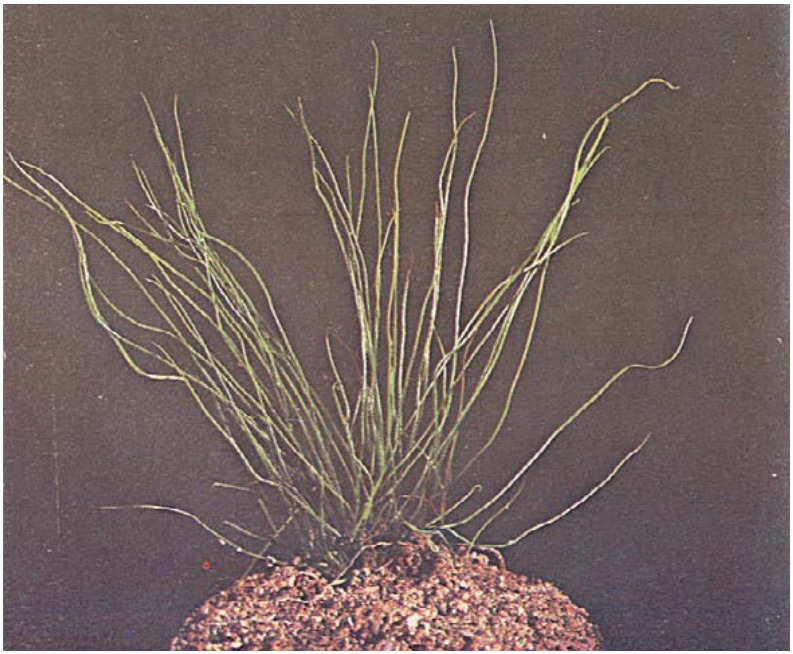
AZOLLACEAE (Azolla Family)

The family consists of minute aquatic ferns floating on the surface or growing in a moist medium as terrestrial forms. The plants have a very short, branching stem. *Azolla,* with six species distributed from the tropics to the temperate zone of both hemispheres, is the only genus in the family.



Marsilea quadrifolia, cultivated emersed.

Pilularia globulifera.

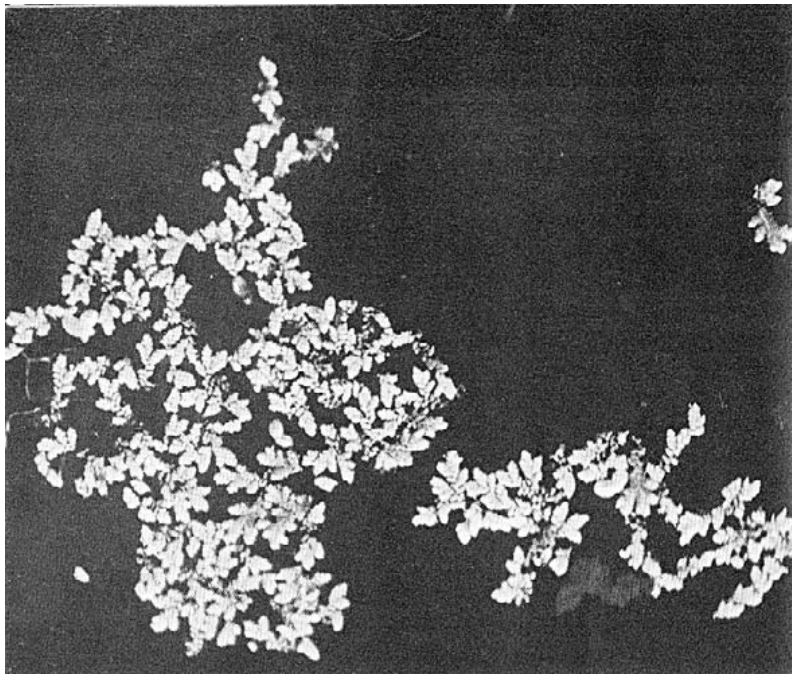




Cryptocoryne parva from Ceylon with inflorescence. Photo by T.J. Horeman.



Close-up photograph of the inflorescence of *Cryptocoryne parva*. Photo by T.J. Horeman.



A small group of floating *Azolla filiculoides*. Photo by Dr. D. Sculthorpe.

These are not desirable plants in aquariums because they can grow too profusely, like a weed. Under different situations in nature *Azolla* is regarded to be an undesirable weed or a very beneficial plant. The *Azolla* - blue-green alga combination fixes atmospheric nitrogen and is widely used as fertilizer and as forage. *Azolla* is best suited for terrariums and paludariums; it can provide small shallow pools with a decorative growth or cover the surface of moist sand with a varied red-green mosaic carpet. The following species of *Azolla* (water-velvet) are cultivated.

AZOLLA CAROLINIANA Willd.

This species is distributed throughout North and South America and the West Indies. It was introduced to Europe and is now found in many places (Germany, Netherlands, Czechoslovakia), often only temporarily. The plants hardly reach a length of 5 to 12 mm and are round in outline. The stem as well as the leaves are often intensely reddish or green with red margins.

AZOLLA FILICULOIDES Lam. (Ill. 114)

This plant, a native of South America, was brought to Europe and now grows in the same areas as the preceding species plus France and Italy. Compared to *A. caroliniana*, the plants are larger (10 to 25 mm). Both species float on the water with the greater part of the plant being above the surface, so with intensive vegetative propagation it does not take long to cover the surface of the aquarium.

SALVINIACEAE (Salvinia Family)

The Salviniaceae is represented by annual to perennial rootless plants floating on the surface of the water. The leaves grow on short stalks; two leaves are green and very hairy, while the third is finely divided and submersed, acting as a root. *Salvinia* is the only genus of the family. It includes 12 species which are found mostly in the tropics of America and Africa (*S. natans* reaches the temperate zone). Due to introduction the family is almost cosmopolitan. *Salvinia* has become a very serious pest in southeastern Africa, Ceylon, and southern India.

These are suitable plants for shading the surface of the water. Propagation is fast. The majority of *Salvinia* species (floating moss), especially those that have well developed root hairs, form a favorable medium for the spawning of fish.

SALVINIA AURICULATA Aublet (Ill. 108, 109)

This species comes from tropical America. It differs from *S. natans* in having round to ovate leaves. In the aquarium it requires water with temperatures from 66° to 77° F (18° to 25° C) and a bright situation. As in the majority of floating plants, it is recommended that the aquarium be covered with a sheet of glass to retain the humid conditions.

SALVINIA NATANS (L.) All.

S. natans is found in the warmer areas of Europe and in eastern Asia. The leaves are elliptical to ovate and 5 to 15 mm long, their surface covered with short, stiff cilia (hair-like processes).

In nature this species grows in quiet backwaters, pools, and canals with slow moving water where during the summer it often forms a very dense growth on the surface of the water, dying off in autumn. In the aquarium it requires a great deal of light; in rooms heated by gas it becomes pale green and often does not last long. Propagation is by runners.



Hygrophila difformis. Photo by Dr. D. Terver.



Inflorescence of *Hygrophila corymbosa*. Photo by T.J. Horeman.

SALVINIA ROTUNDIFOLIA Willd.

S. rotundifolia comes from South and Central America. The leaves are round, 10 mm long, and densely covered with cilia. It grows in pools and ponds and requires warmer water.

SALVINIA MINIMA Bak. (Ill. 105)

This species is probably the most convenient for aquariums. It grows well at temperatures from 20° to 32° C, winters well, and endures oscillation of the pH. Although it comes from South America (from Santa Catarina, southern Brazil), it can be used together with cryptocorynes. Its rounded, nearly sessile leaves are only 6 to 9 mm long. Submersed leaves are divided into 5 to 6 segments (each 25 to 76 mm long) and look like roots. In the water they form a thick network of greyish white or pinkish "rootlets" in which young viviparous fish like to live. Islets of floating plants serve as spawning plants to many species of fish and are used for building bubblenests by fightingfish and gouramis.

MARSILEACEAE (Marsilea Family)

This family is comprised of amphibious ferns that are rooted on the bottom with submersed, floating, and aerial leaves as well. Some species develop terrestrial forms. This family of perennial plants includes three genera: *Marsilea* (about 65 species), *Pilularia* (6 species), and *Regnellidium* (1 species). They have a creeping rhizome with developed roots at the base. The leaves are of various shapes and arranged mostly in two rows on the rhizome; young leaves are rolled. The plants live mainly in a marshy environment and are propagated by division of the rhizome.

MARSILEA (PEPPERWORT) (Ill. 30)

The leaf stalk is long, terminating in four leaflets which are arranged symmetrically cross-wise; the plant is submersed, floating, or emersed. Its distribution ranges from the tropics to the warmer areas of the temperate zone of both hemispheres. Only two species are fit for the aquarium: the European *M. quadrifolia* and the Australian *M. browni*. All the other species are suitable only for paludariums and terrariums, as they do not grow under water. In nature *Marsilea* is found in ponds, ditches, swamps, rice paddies, and other areas with standing water. Several species are regarded as troublesome weeds in rice fields and irrigation ditches.

MARSILEA BROWNII R. Br.

This species comes from Australia, growing there in marshes as an amphibious plant. The smallest of the imported species, in its

terrestrial form it has petioles that are not more than 80 mm long. The leaves are smaller than in the other species. Juvenile foliage is glossy, but later develops a soft downy or ciliate covering. This species forms sporocarps more readily than others. Under water only simple to 2-parted leaflets are formed on the petioles. The plants reach a maximum height of 25 to 50 mm.

This plant propagates as speedily in deep water as in a marshy habitat, the thin rhizomes taking root quickly. During summer a dense green or olive carpet is formed on the bottom. It is best cultivated in soft, moderately acid or neutral water and is the most suitable species for aquariums and terrariums. It hibernates in all forms.

MARSILEA QUADRIFOLIA L. (Ill. 112)

M. quadrifolia is found in central and southern Europe, Caucasia, western Siberia, Afghanistan, southwestern India, China, Japan, and North America. It has a long creeping rhizome from which leaves similar to a four-leaf clover develop in two rows.

In the aquarium this species should be cultivated in sand and in the shade. Only in this way will it prosper under water, the petioles growing to a length of 10 to 15 cm. In bright situations the petioles become elongated and the leaves reach the surface and emerge from the water. It is less suitable for paludariums and terrariums as in these situations the plant develops petioles that are up to 20 cm long and become prostrate.

PILULARIA (PILLWORT) (Ill. 112)

This genus contains minute plants with narrow cylindrical leaves; the juvenile foliage is coiled as in other ferns. They are generally found on the banks of shallow waters. Only *P. globulifera* is cultivated.

The rhizome is 20 to 50 cm long (in submersed forms it can grow to 2 meters), creeping, pilose or bare, and densely covered with cylindrical leaves which are 2.5 to 10 cm long in land forms and 30 cm long in submersed forms.

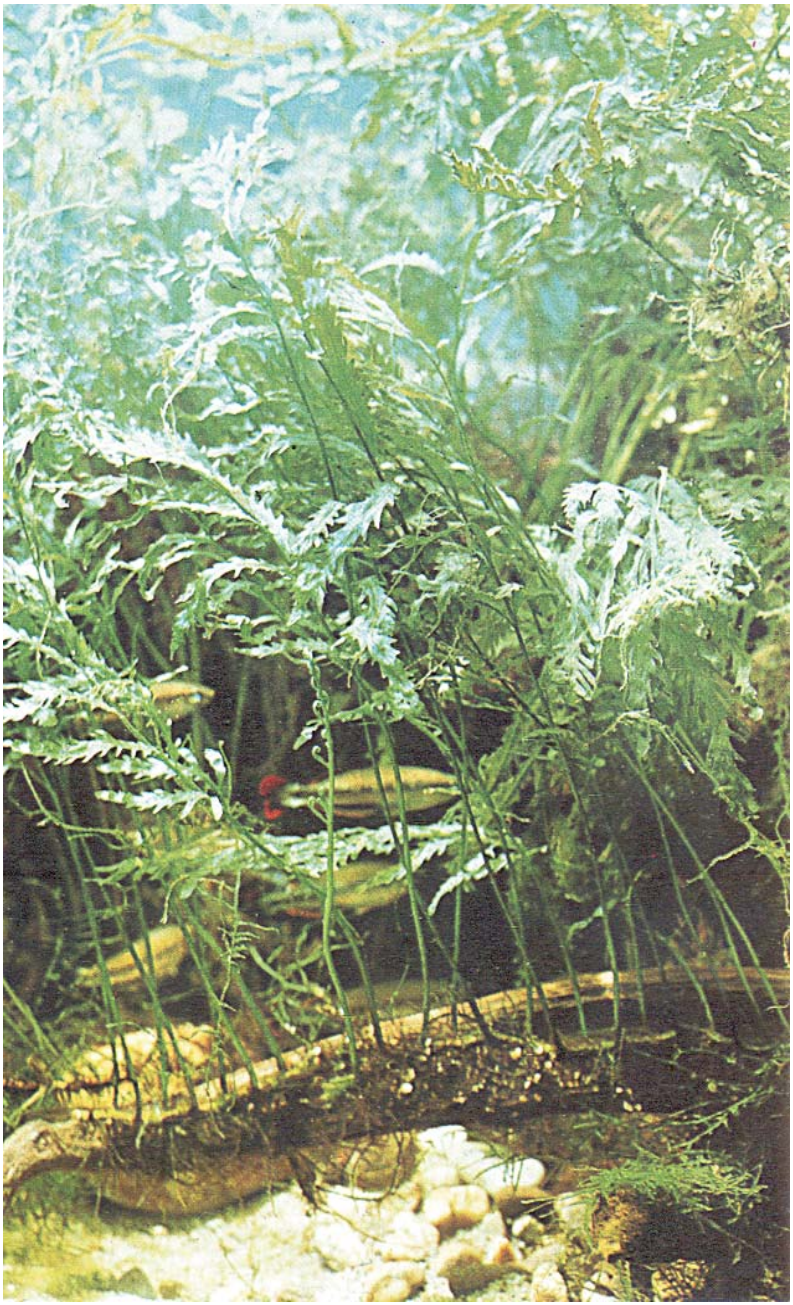
It grows in shallow water in pools and ponds, most frequently on substrates ranging from sand to fine silt. The plant is sensitive to alkaline conditions and prefers cool waters but temporarily withstands higher temperatures. Under water it usually dies at the approach of winter, a disadvantage which makes it more suitable for terrariums, where it can form an attractive carpet.

REGNELLIDIUM (Ill. 109)

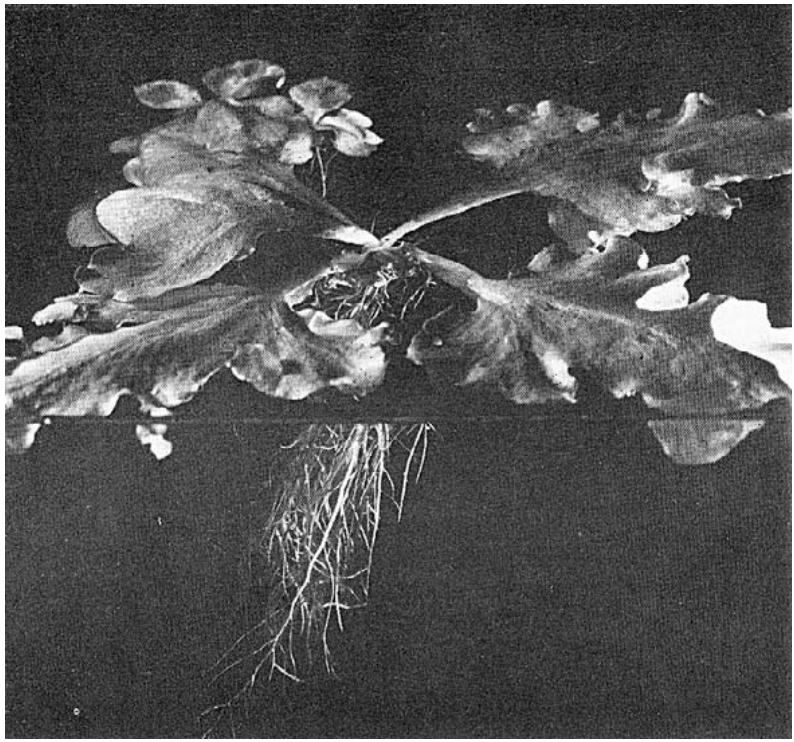
Except for having only two leaflets this genus is like *Marsilea*.



Ceratopteris thalicroides. Photo by Dr. D. Terver.



Bolbitis heudelotii. Photo by Dr. D. Terver, Nancy Aquarium.

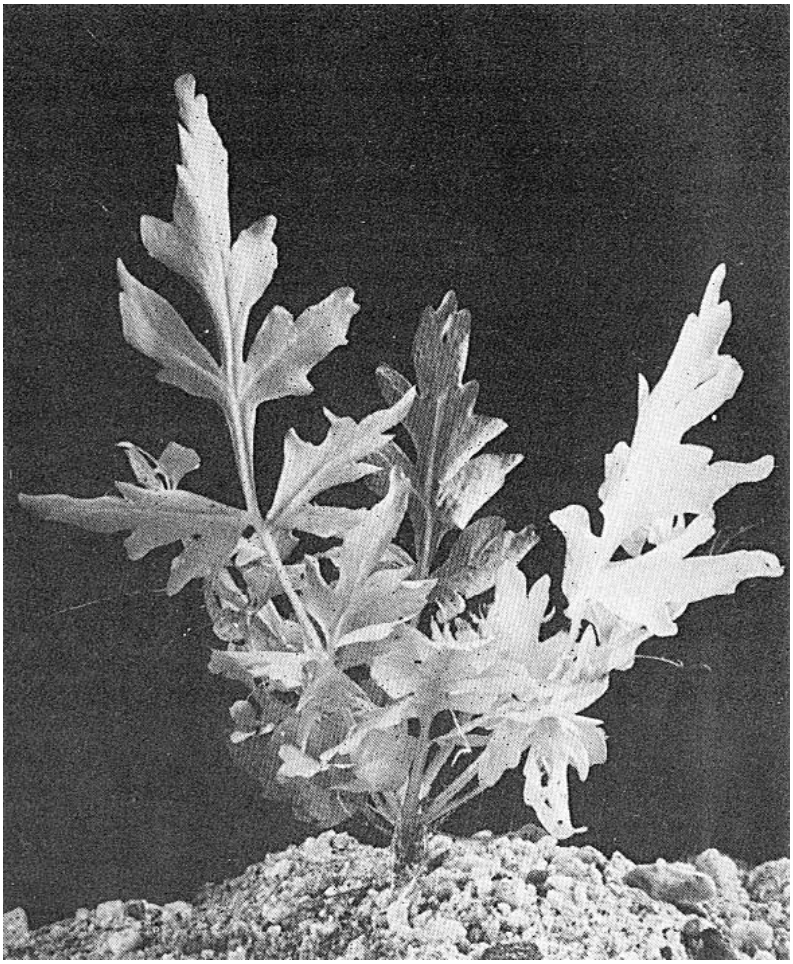


Ceratopteris pteroides is an appropriate plant for spawning fish. Newly hatched fry can seek protection in its fine root system.

The unique *R. diphyllum* Lindm. is endemic to southern Brazil and northern Argentina. Although regarded as an aquarium plant, this species does not grow under water permanently and is suitable only for paludariums.

CERATOPTERIDACEAE (Parkeriaceae) (Ceratopteris Family)

This family (with the single genus *Ceratopteris*) consists of annual floating or rooted ferns living in water or marshes. The leaves are of various shapes and sporangia are formed on their lower surface. *Ceratopteris* (6 species) grows in the tropics and subtropics and is mainly confined to shallow waters. The plants are propagated partly by axillary buds on the leaf margins and partly (during maturity) by generative reproduction from spores which germinate readily. Propagation in the aquarium is similar to that of *Isoetes*. (Ill. 81)



Ceratopteris thalicroides.

All cultivated species are usually regarded in existing aquarium literature as forms or varieties of a single species, *C. thalicroides*. Plants with wide leaf blades are labeled as *C. thalicroides*, plants with deeply indented leaves as *C. thalicroides* var. *javanicus*, and floating plants as *C. thalicroides* form *cornuta*. The identity of floating plants of *C. cornuta* (P. Beauv.) Lepr. coming from Africa is doubtful. They often represent the following three species:



Hygrophila difformis. Photo by T.J. Horeman.

Hygrophila corymbosa.





Inflorescence of *Echinodorus berteroi*.

Echinodorus berteroi.



CERATOPTERIS PTEROIDES (Hooker) Hieron (Ill. 122)
(FLOATING WATER SPRITE)

C. pteroides extends to tropical Asia and America. Rosettes of four to six leaves are formed. The petioles are flat, green, 25 to 75 mm long, and widen into lance-shaped or heart-shaped blades. The leaves are sometimes nearly entire, but their sides are usually incised and resemble oak leaves. On the margins or on the ribs new plantlets arise that separate (in this way become islets). The widely branched roots form an ideal hiding place for viviparous fish. At the same time they serve as a suitable spawning medium for many species of aquarium fish. Gouramis like to build their bubblenests among them.

C. pteroides is grown on the surface of water that is acid and soft and has a minimum temperature of about 18° C, although it grows best with 25° to 30° C. Sometimes it propagates too rapidly, but the number of plants can be reduced. This plant dislikes hard and alkaline water but does not mind plenty of light or half-shade.

CERATOPTERIS THALICROIDES (L.) Copel (Ill. 120, 123)
(WATER SPRITE)

The leaves (50 to 80 cm long) have petioles that are three to seven times shorter than the blade, which is green, flat, and very fragile. The blades are deeply incised, but the indentation does not reach as far into the petiole, so the rib is 12 to 25 mm wide. The blades are typically odd-pinnate and the leaf segments are 25 to 75 mm wide. In older literature it is characterized as a broadleaved fern.

This species prefers acid waters (pH 5-6.5) and deeply shaded places. Its bright green color and incised leaves serve as a most suitable complement to cryptocorynes. Having a rather poor root system, it gets nutriment mainly from the water. It is an annual plant. To keep it alive during winter the light has to be prolonged to 12 hours a day or it will die. Some of the youngest spirally twisted leaves can be saved and will develop in the spring. *Ceratopteris* is tasty food for aquarium snails. During the period of retarded growth (especially in winter), the number of snails has to be reduced; only smaller individuals up to 12 mm can be kept.

CERATOPTERIS SILIQUOSA (L.) Copel (Ill. 127)
Incorrect name: *C. thalicroides* var. *javanicus*

The leaves are 25 to 113 cm long, with petioles narrower than in the preceding species; deep incisions reach to the petioles so they are typically odd-pinnate. The individual segments of the leaves

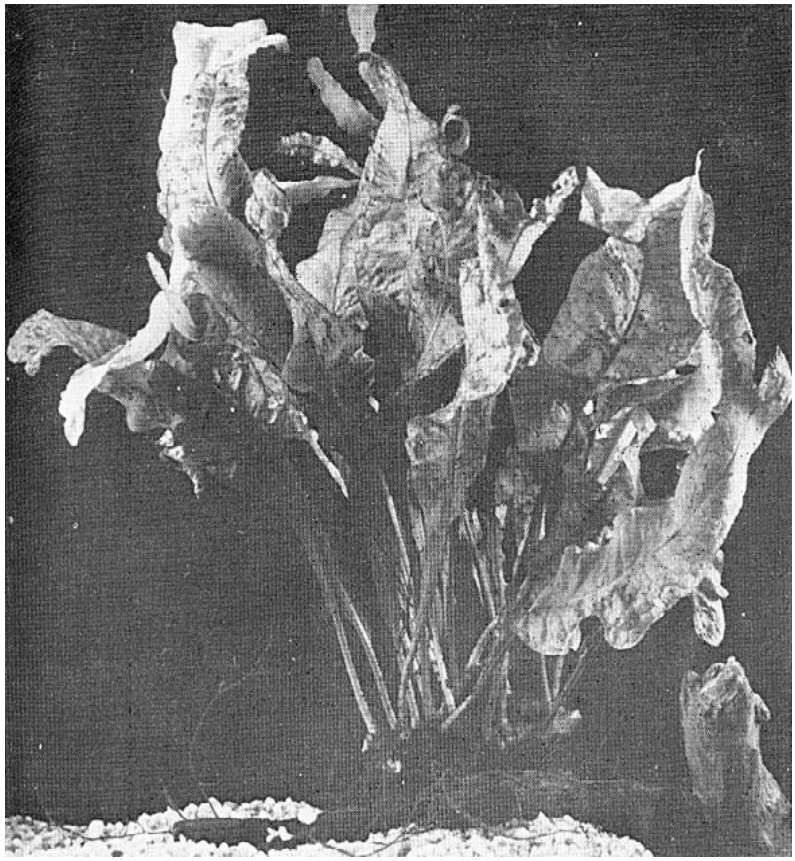
grow on the petioles in pairs standing against each other as well—thus a double odd-pinnate leaf. The leaves are much more ragged, the individual segments only 2.5 to 7.5 mm. It is cultivated in the same conditions as *C. thalicroides*, but is more decorative and grows easily. It is amphibious and often forms emersed leaves, so it can be grown as a terrestrial form in paludariums, where it reproduces quite easily also.

Ceratopteris siliquosa.





Microsorium pteropus (broad-leaved plant in background). Photo by Dr. D. Terver.



Microsorium pteropus.

POLYPODIACEAE (Polypody Family)

The Polypodiaceae is the largest family of ferns and contains perennial plants with a prostrate rhizome. Juvenile foliage is spirally coiled. The blades are copiously divided or only lobate, rarely smooth-edged. Many species grow on moist, periodically flooded soil. Only two species are cultivated in aquariums.

MICROSORIUM PTEROPUS (Blume) Ching (JAVA FERN)

M. pteropus comes from India, southern China, and the Indo-Malayan area as far as the Philippine Islands, where it is found as an amphibious plant attached to old tree trunks, stones, or the ground.

The plant has a creeping rhizome from which dark brown plume-like petioles develop with leaf blades that are 10 to 25 cm long and 25 to 75 mm wide. The blades are wide, lanceolate, smooth-edged, and green to brownish green with a distinct nervation; leaf margins are undulate.

This is one of the most beautiful aquarium plants. It is not exacting with respect to the composition of the water and grows well in a good light as well as in more shaded positions. Reproduction is by the separation of daughter plants which arise on the leaf margins of fully developed specimens and take root readily.

To cultivate this fern it is necessary to attach it to submersed branches or fasten it to the rocks used as decorations in the tank. After some time the roots become firmly attached. It should never be planted in sand. *M. pteropus* requires temperatures of about 68° to 77° F (20° to 25° C). Very suitable for paludariums, it grows over rocks, stumps, or branches but requires artificial illumination.

BOLBITIS HEUDELOTH (Bory ex Fee) Alston (Ill. 121)

The interesting water fern *B. heudelotii* comes from Guinea in tropical Africa. Its leaves are 25 to 37.5 cm long, odd-pinnate, with five to seven incisions on both sides of the blades, which are dark olive green, bottle green, or brownish. Cultivation is slightly more difficult than with the preceding species. *Bolbitis* is not planted in the bottom, but the plants can be fastened to stones or roots used as decorations in the aquarium. It demands a clear, soft to medium hard water and temperatures from 72° to 82° F (22° to 28° C). It does not do well in thickly planted tanks. This plant likes moving water and grows well when placed next to the filtering system, which enhances their normally slow growth. Sometimes algae can stop the development and growth of these plants, nor should there be too many fish in the tank. Successful aquarists often cultivate this species on decorative roots together with fish of the genus *Aphyosemion*.

Other species like *Bolbitis fluviatilis* (Hook.) Ching from tropical West Africa, *B. hydrophylla* (Copel) from the Philippines, and *B. lonchospora* (Ktze.) C. Chr. from Polynesia should also be considered for the aquarium. Even their names (*fluviatilis*, *hydrophylla*) indicate that they are water ferns.

Flowering Plants (Spermatophyta)

This group includes those plants with a perfectly developed body generally possessing roots, stem, leaves, flowers and fruit—in the botanical sense. They are divided into gymnosperms (conifers, cycads, etc.) and angiosperms (all flowering plants). The angiosperms are separated into two important divisions: monocotyledonous plants and dicotyledonous plants. The dicotyledons (Dicotyledonaceae) germinate from seeds with two flat, usually horizontal leaves; the monocotyledons (Monocotyledonaceae) germinate with only one, usually vertical, leaf. These differences are not important to the aquarist, so all the flowering plants presented here are arranged in alphabetical order by their family names.

ACANTHACEAE (Acanthus Family)

These are herbs or shrubs, rarely trees. They are mainly species of the tropics and subtropics, but some of them grow in warm areas of the temperate zone; they are found in forests, steppes (prairies), meadows, and marshes, as well as on inaccessible rocks and on the borders of deserts; some grow high in the Himalayas and Bolivian Cordilleras. Some species of this family have a very limited distribution. The family is large and contains about 250 genera with 2,650 species. Only a limited number grow submersed, but probably many of these will become aquarium plants in the future. In addition all are very suitable for planting in shallow containers.

Recently there have been many important changes in the nomenclature of the family. The genera *Asteracantha*, *Nomaphila*, and *Synnema* are no longer regarded as independent genera but are now all placed in the genus *Hygrophila*. Today the family Acanthacea includes only two aquatic genera, *Justicia* and *Hygrophila*.

The genus *Justicia* (about 300 species) is tropical and subtropical. Many species are marsh plants. *J. americana* (L.) Vahl. is aquatic and the cause of some concern in southeastern North America. Dense stands of this plant are the favorable breeding places for malarial mosquitos. It is not a very attractive plant and is not cultivated in aquariums.

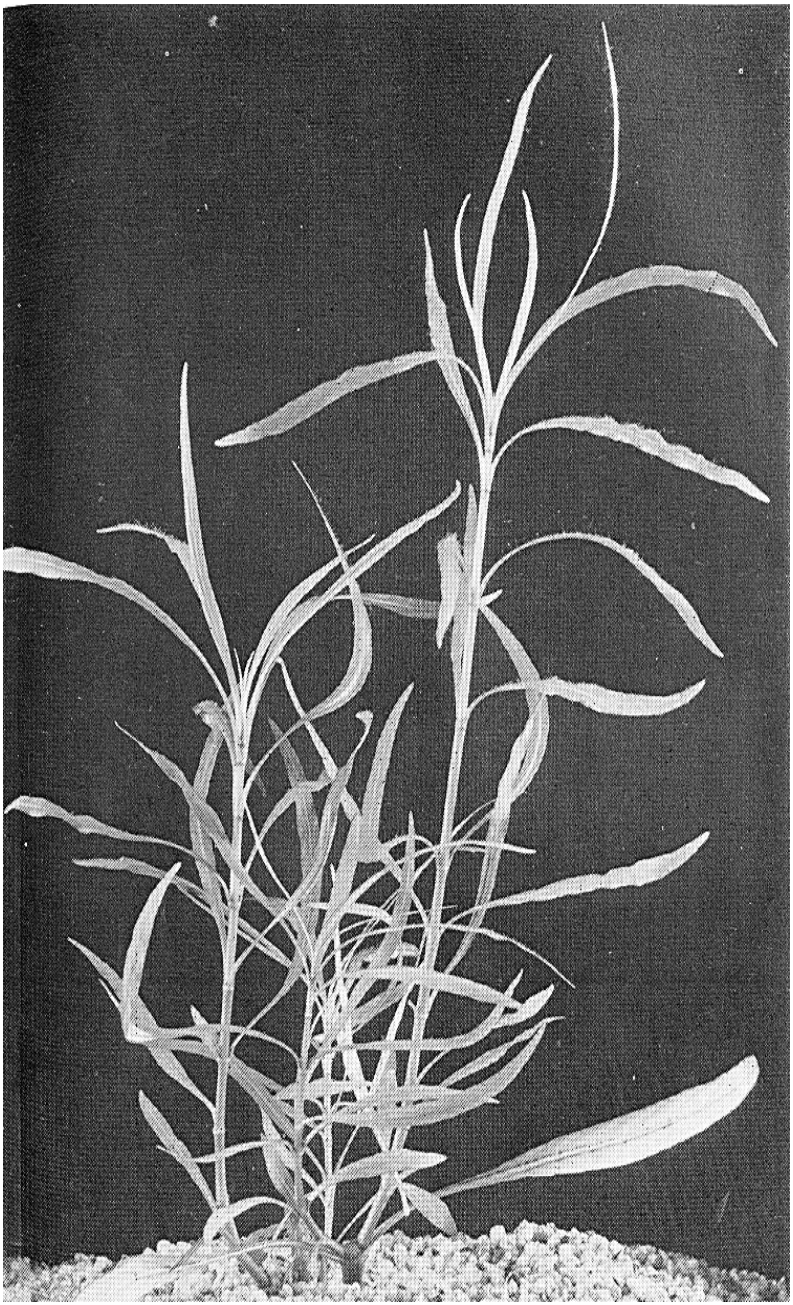
The genus *Hygrophila* has an erect or ascending stem. The leaves are opposite, entire, lanceolate to obovate, with many species heteromorphic, having very variable emersed or submersed plants. Flowers arise in the leaf axil and are minute, with a deep two-lipped corolla, white or blue to purple. Emersed plants are usually finely pilose; submersed plants are naked. About 80 species grow in the tropical areas of the world.

The plants can be cultivated emersed as well as submersed. Although growing well under water, they adapt to normal soil conditions and can be cultivated in flowerpots as indoor plants. They flower abundantly and produce seeds. Some larger species grow very slowly under water, so they are propagated in tanks with water to a height of 10 to 15 cm, allowing them to grow quickly and form profusely branching stems. If the tips are cut off and planted in deeper water, they take root fast and within a week the stems and leaves lose the typical short soft hairs and the appearance of emersed plant growth is changed to that of submersed growth.

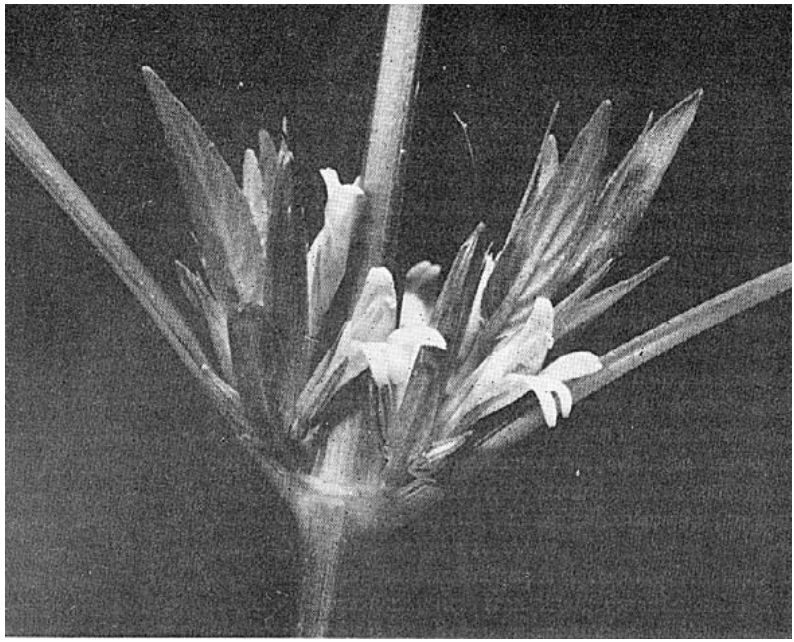
Hygrophila plants when cultivated in water require a moderately rich sand and soft or moderately hard water that is slightly acid to slightly alkaline. Some species require generous light, but others tolerate a certain amount of shade. Species from the tropics are usually the ones that are cultivated in aquariums.

HYGROPHILA ANGUSTIFOLIA R. Br. (Ill. 133, 134)
Syn: *Hygrophila salicifolia* Nees.

This species comes from tropical eastern Asia, Indonesia, Australia, and New Zealand. The stem is often 10 mm thick, with leaves that are opposite, lanceolate with indistinct veins, 12 to 15 cm long, and 10 to 15 mm wide. The leaves are straight, have entire margins, are naked, and are light green above and whitish green below. Submersed leaves are only 7.5 to 10 cm long and 5 to 10 mm wide and richly branched. The plant blooms only in the emersed form. In marshy conditions they can form a densely branching bush 1 to 1.5 meters high, resembling the willow (*Salix* spp.). Tips cut from the emersed plants and transferred into water take root very readily, developing a stalk with long decorative



Hygrophila angustifolia.



Inflorescence of *Hygrophila angustifolia.*

leaves. The tips of these plants (when well-rooted) are cut off to make them spread further and form profusely branching tufts 40 to 50 cm high.

H. angustifolia is best cultivated in a medium rich soil with soft or moderately hard water in a lighted situation. The plant is thermophilic (68° to 77° F (20° to 25° C)); lower temperatures will do no harm even though the lower leaves often are lost. The acclimatization of emersed plants into an aquarium environment is sometimes very lengthy or unsuccessful.

HYGROPHILA CORYMBOSA (Blume) Lindau (Ill. 117, 124)
Syn: *Nomaphila stricta* (Vahl.) Nees.

This *Hygrophila* species is from the Malayan area, where it grows as a robust marsh plant with both emersed and submersed leaves. Above water it forms stems up to 10 mm thick with opposite leaves that are about 10 cm long and 50 mm wide, very broadly lanceolate, nearly cordate, tapering into an extended apex, and with serrate margins. The whole plant (especially the stem) is pilose, brownish green to reddish green.

The growing points transferred to underwater conditions take root very quickly and become naked. Within ten to twenty days the leaves change to a light green, but do not grow to be as broad as those of emersed plants. They are 25 mm long and are not too distinctly serrated. The now green stem becomes swollen at the nodes rather like bamboo. The upper leaves keep the reddish coloration. It is one of the most beautiful plants.

This plant is cultivated in aquariums with a fairly rich planting material and with any type of water. It requires a well illuminated situation but is content with artificial light; grows very quickly in temperatures above 68° F (20° C).

In winter the plant should be given artificial light, otherwise the bottom leaves are lost; in such a case at the beginning of spring the heavy part of the stem has to be cut off and replanted. Propagation is by planting pieces detached from the stem. These pieces can also be cultivated in flowerpots where they develop very well if lighted properly. They need to be watered well every day.

HYGROPHILA DIFFORMIS (L. fil.) Blume (Ill. 116, 124)
(WATER WISTERIA)
Syn: *Synemma triflorum* (Roxb. ex Nees.) O. Kuntze

H. difformis can be found as an erect or prostrate plant in the Indo-Malayan area. The stem is thin and rooted. The leaves are opposite, light green in color, the lower submersed leaves divided or deeply incised and 7.5 to 10 cm long and 25 to 50 mm wide. The upper leaves are at first nearly smooth-edged, later changing and featuring the same form as the lower leaves. Aerial leaves are smooth-edged, not more than 50 to 65 mm long, and finely pilose. Roots usually appear at the nodes.

This plant is cultivated in soft to medium hard water in diffused light; it requires less light than the other species of the family. Artificial light suits it very well, but in indirect sunlight it sometimes becomes pale. It is a thermophilic plant that requires 68° to 77° F (20° to 25° C); although it grows below 68° F (28° C), submersed leaves are then smooth-edged and less ornamental. Growth ceases at 59° F (15° C).

H. difformis is a very beautiful aquarium plant which under favorable conditions is propagated very quickly by planting fragments of the stem. With its light green leaves it is a suitable complement to darker brownish green plants. By cutting off the tips of the stems some profusely branching plants can be obtained whose shape and size may be freely arranged as desired or needed.



Hygrophila lacustris.

HYGROPHILA LACUSTRIS (Schlect.) Nees. (Ill. 136)

This is among the latest novelties of the genus *Hygrophila*, being imported as recently as 1971 and 1972 from Thailand. Emersed plants resemble *H. angustifolia* but are always quite naked and the leaves are longer and wider. *H. lacustris* in comparison to *H. angustifolia* is more easily acclimated. Emersed plants transplanted under water root very quickly and without exceptions grow immediately. Submersed leaves are usually shorter at the base of the plant, prolonged upward to a length of 10 to 12.5 cm, and can be up to 25 mm wide though usually only 10 mm.

In any case *H. lacustris* is much more suitable for indoor aquariums than *H. angustifolia*. It grows well in slightly alkaline water in light and half-shade. It is one of the most resistant aquarium plants and should become very popular.

HYGROPHILA LANCEA (Thunb.) Miq.

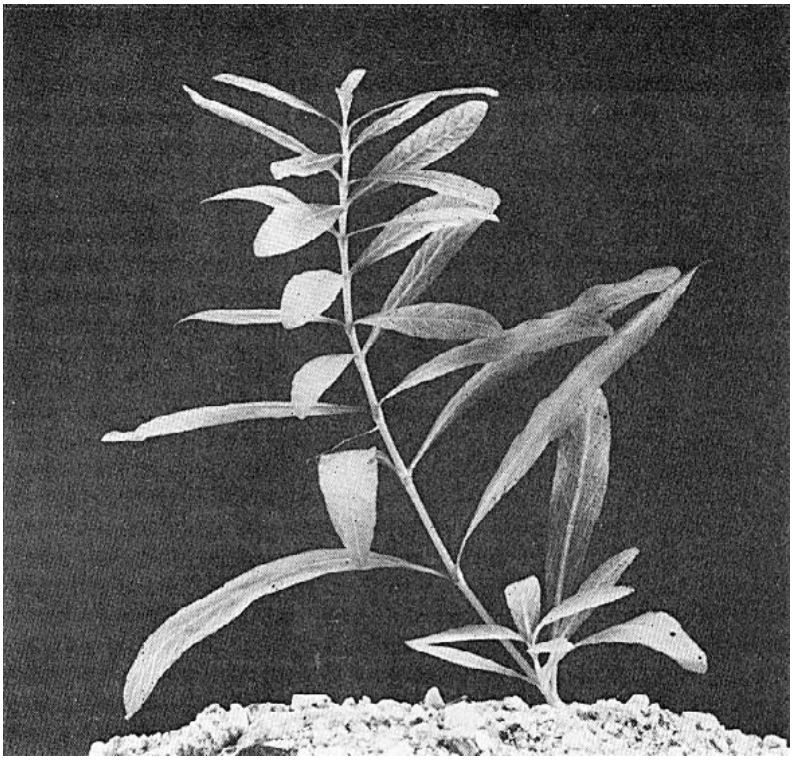
H. lancea is native to Japan and Taiwan and is one of the lesser known but very suitable aquarium plants. It reaches a height of 50 to 60 cm, with a stem 8 mm in thickness and leaves that are opposite, lanceolate, and 50 to 75 mm long and 10 to 20 mm wide. The veins are elevated and conspicuous. The whole leaf blade is moderately curved with curled margins. It grows very quickly in the emersed form, and its stems and leaves are almost naked. In the submersed form it grows more slowly and in appearance does not differ very much from plants grown out of the water. The plant is light green and very decorative.

This species, cultivated in a bright place at temperatures around 68° F (20° C), requires neutral water. After being transplanted it as a rule grows toward the surface. If the tip above the second or third pair of leaves is cut off, the axillary buds begin to grow and a very decorative little shrub develops.

HYGROPHILA POLYSPERMA (Roxb.) T. And. (Ill. 138)

This marsh plant originated in India. Among all the cultivated species of *Hygrophila* it is the one best adapted to submersed existence.

Specimens cultivated under this name for some forty to fifty years have never flowered. Their identity is therefore uncertain. Among the imported plants of the last few years have appeared plants similar in the submersed form, but in the emersed form with top leaves clearly hairy; the plants flower easily and regularly. These flowering plants have been reliably determined without doubt to be *H. polysperma*. Is the plant cultivated for so many



is propagated by runners from the creeping stem. This species is cultivated in a sandy medium, with any kind of water, in a generously lighted situation; it tolerates low as well as high temperatures. Growth is inhibited in the winter, but hibernation takes place even in well lit tanks.

HYDROCOTYLE LEUCOPETALA Cham. et Schlecht. (Ill. 182)

H. leucopetala (from South America), unlike *H. vulgaris*, has petioles that do not lead into the middle of a shield-shaped blade; instead the blade is deeply cut from the edge to the center, so that the petiole runs into the deepest point of this cut. Stems are usually under water or float on the surface, where they flower easily and reproduce. The dimension of blades is variable, from 25 to 75 mm. If the plants are used in their floating form (not rooted) the blades are usually small. It is better to plant them into the medium and cut off the tips as soon as the stems reach the water surface. *H. leucopetala* demands plenty of light but is not particular as to the quality of water and other external conditions.

Occasionally one will come across the species *H. verticillata* Thunb. from tropical South America, together with *H. leucopetala*. They differ in the shape of the blades; the leaf edges in *H. leucopetala* are nearly entire or only shallowly cut, while those of *H. verticillata* have deep cuts sometimes consisting of five nearly symmetrical lobules.

LILAEOPSIS (Ill. 193)

Lilaeopsis includes 14 to 20 species distributed in North America and South America, Australia and New Zealand. Most of the species are found on the shores of brooks or submersed in rivers and lakes; some are found in brackish water. Others, like *L. lacustris* A.W. Hill, are found deeply submersed in water as deep as 4 meters in New Zealand. The stems are creeping or floating, rooting mostly at the nodes. Leaves are erect, reduced to simple septate leaf stalks, entire, subulate, linear or spathulate.

Only *Lilaeopsis novae-zelandiae* A.W. Hill is commonly cultivated. It is a tiny plantlet, about 25 to 50 mm tall, of a bright green color, especially suitable for planting in the front of an aquarium. Its creeping stock branches very quickly and rapidly make a thick green carpet completely covering the bottom of the tank. Each plant has only one to three leaves. Being so delicate, it is not available in large quantities commercially. It is difficult to find for sale, and aquarists help each other by way of exchange. This is one reason why *L. novae-zelandiae* is little known as an aquarium

plant. It grows exceptionally well and is not particular about the quality of the water or the light; it is just as beautiful in the aquarium during summer as in winter.

APONOGETONACEAE

Aponogeton, the only genus in the family Aponogetonaceae, is distributed in the tropical and subtropical areas of the Old World. It is absent in the New World (except for the introduced *A. distachyus*). About 45 species are known.

The plants commonly cultivated in aquariums come mainly from tropical Asia. They grow in India and farther to the east; on the eastern coast of Asia they extend well to the north, as far as South Korea; they are found even on some islands of the Indo-Malayan area. From these parts come the most popular and most resistant species, i.e. *A. crispus*, *A. undulatus*, and *A. natans*. Recently some new species propagated vegetatively have been imported from Asia.

In Australia it is mainly *A. elongatus*, a species that is very suitable for aquariums, that is recorded.

Aponogeton is found throughout the African continent, but no African species is suitable for use in the aquarium. They are usually plants requiring a rather long resting period and should be taken from the aquarium and put into a moderately moist sand over winter (e.g. *A. leptostachyus*). Other species are not amphibious and cannot withstand permanent underwater conditions (e.g. *A. junceus*). Some species (*A. distachyus*) are robust, up to 1 meter tall, and develop large, floating leaves; on account of this, they are unsuitable for aquariums. They are best used for planting in garden pools and the like. *A. distachyus* is very resistant and hibernates even in low temperatures. It has been brought to Europe (to southern France) and to South America (Peru). It flowers abundantly and forms seeds easily. There are horticultural varieties with pink or white flowers.

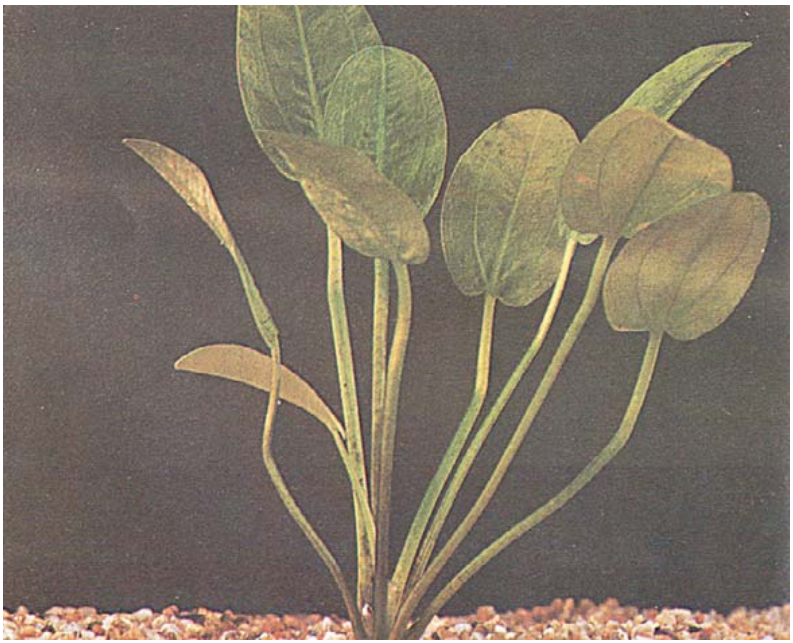
Very interesting and decorative too are the species found in Madagascar. The exquisite *A. ulvaceus* has long been useful in the aquarium.

Aponogeton species are principally submersed plants, those from Asia, Australia, and Madagascar being typically submersed representatives. Species from the African continent are generally submersed only during the rainy period; they drop their leaves later and survive the dry period with the help of starchy tubercles.



Echinodorus horizontalis. Photo by T.J. Horeman.

Echinodorus longiscapus.





Echinodorus intermedius collected in Paraguay. Photo by T.J. Horeman.

Echinodorus grandiflorus found in swamps near Mage, Brazil. Photo by T.J. Horeman.



Some species, such as *A. junceus*, have become adapted still further and can develop emersed leaves. They can withstand water up to 10 cm deep and live, though poorly, in this submersed state.

In nature plants of this genus are propagated mainly from the seeds. This is also true for plants cultivated in the aquarium, except those species forming rhizomes. The rhizomes can be divided, and two to four new plants will develop from a single plant. This is possible, for instance, with well-developed individuals of *A. madagascariensis*. Only two species are propagated vegetatively: *A. undulatus* (= *stachyosporus*), which develops tubercles on the floral stalks from which leaves and roots grow, and *A. rigidifolius*, which forms a horizontal rhizome on which new plants arise.

The species of *Aponogeton* are practically the only aquarium plants that must be virtually propagated from seeds. Above water these plants develop spicate inflorescences consisting of a great number of minute white, yellow, bluish, or pink flowers. The Asiatic and Australian species form one single spike on the floral stalk, and the African (including Madagascar) species exhibit a forked inflorescence with two to five spikes.

The pollen is usually transferred by tiny insects visiting the sweet and colored flowers where these plants are cultivated. In greenhouses the pollen is transferred in the same way, but in the aquarium it is necessary to pollinate the flowers artificially. *Aponogeton* flowers are self-sterile as well as self-fertile, i.e. they can be pollinated by both the pollen of the same individual plant and by pollen of another plant of the same or a different species. That is why hybrids are formed easily.

In artificial pollination either a fine brush or a piece of soft cloth or gauze wound on a small stick, etc., is used. If several flowers in one or more plants mature at the same time, they are best pollinated by holding one flowering spike above the other and giving it a moderate shake; clouds of yellow pollen then fall upon the lower spike and the grains stick to the stigmas.

We are of the opinion that the success or failure of artificial pollination of *Aponogeton* species is not dependent upon the method of pollination, but upon the conditions the plants have during their development. Our thinking is based on the fact that in certain years the seeds of *Aponogeton* mature in indoor aquariums for some people, whereas in other years the seeds do not develop in spite of being pollinated artificially.

It is certain that the members of the genus *Aponogeton* develop better and form seeds readily only when the illumination is

from above—in ponds, in tanks placed near the floor, below the window, etc. Also of great importance are the composition of the medium and water and the number and kinds of fish in the tank. The common Asiatic species and their hybrids develop seeds regularly in greenhouses and ponds.

The seeds are relatively large (50 to 75 mm) and are enveloped in follicles filled with air so that mature seeds float and are transported by water; thus new plants can be distributed far from the parent plants. After about 24 hours the seed coating splits open and the seed sinks to the bottom. It usually germinates at once, and within a few days little roots develop and allow it to take hold. Mature seeds can be separated easily from the axis of the spike. They are collected before they fall off naturally, because if left to separate spontaneously many of them get lost in the dark corners of the tank or pond, where they cannot develop.

The seeds are sown on the surface of washed sand and then transferred into tanks some months later. Development is better if the seeds are kept in a bottle of clear water for a period of four to eight weeks and are transplanted (to tanks without fish) only when their leaves are about 25 mm long and the roots about 50 mm long.

The propagation of *Aponogeton* from seeds is elaborate and slow and requires special tanks without fish. As a rule neither the seeds nor the young plants develop if put into tanks holding fish. It will be more advantageous for the aquarist to acquire pre-cultivated seedlings or fully developed plants from aquatic plant shops. In species propagated vegetatively, the young plants developing on the floral stalks are separated only after some short rootlets have been formed. One parent plant can provide up to twenty new ones from four to five stalks during the vegetative period.

True species of *Aponogeton* (i.e., those which are not hybrids) are difficult to cultivate. They require generous overhead light. A customary error committed by aquarists is to cling to the opinion that the *Aponogeton* species do not require a rich soil. This belief arose from the fact that a mature plant with a good tubercle can live in clean, washed sand without further nourishment for four to eight months and that it continues forming new well developed leaves and flowers as well. A plant like this grows from food reserves stored in the tubercles, so it needs only a small amount of nutrients drawn from the water. But in due course the supply of energy will be exhausted and the plant will stop growing or possibly die. Its tubercle is then to be found shrunken, half-empty, or starting to rot.



A part of the inflorescence of *Echinodorus macrophyllus*.

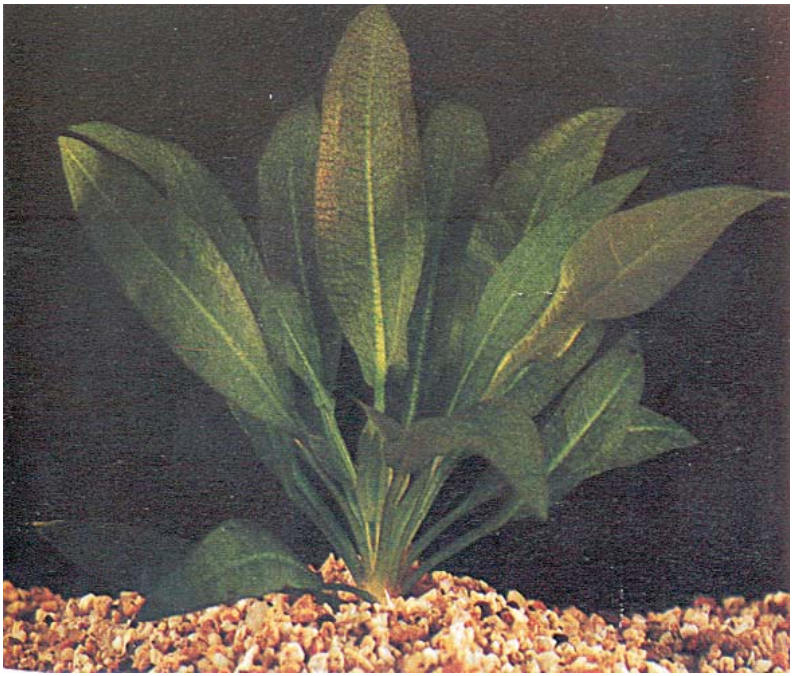
Echinodorus macrophyllus.





A part of the inflorescence of *Echinodorus parviflorus*.

E. parviflorus, submersed plant with dark veins.



The plants obtained from imported tubercles should be cultivated therefore in tanks with a planting medium supplied with nutrients. In older tanks where the bottom is enriched by detritus, they all do well except for certain kinds with gauze-like leaves. The soil should not contain lime, nor should the water be too hard.

Genuine *Aponogeton* species should be given conditions which maintain their natural rhythm of development, *viz.* a period of vegetative growth (March to May), flowering period (May to June), maturation of seeds (June to July), and a period for building up reserves in the tubercle (August to October); they then should be given a resting period. This task is achieved by not heating the tank in winter, letting the temperature fall to between 46° to 50° F (8° to 10° C) from November to January. During this period of dormancy the plant as a rule drops all its leaves. In February or in March the temperature is raised to 64° to 68° F (18° to 20° C). Within a few days the tubercles react to this temperature by starting to develop leaves, which can reach a length of up to 20 cm within a fortnight (*A. ulvaceus* is an example). The growth of the plants from tubercles treated in this manner is then very fast. They produce abundant flowers and develop seeds readily by self-pollination. This system is not possible in a tank with fish, and it is recommended only in the case of parent plants from which one wants particularly to obtain young plants.

The situation is different in the case of hybrids, which form the great majority of *Aponogeton* plants in aquariums. These hybrids have been developing over a long period, and natural selection under aquarium conditions has made itself felt, so they are adapted to life in tanks and grow well all the year round. Since they live in warm water all the time, they do not develop the typical tubercles, or they form small ones that appear only as thickened rhizomes hidden in the tangle of roots. They can flower any time, often in winter. The hybrids designated as *Aponogeton hybridus* Hort. and developed by the inter-crossing of *A. echinatus* and *A. natans* are therefore ideal aquarium plants. They withstand artificial illumination well not only from above but also from the sides and are indifferent to moderately hard water. The utilization of these hybrids rather than the genuine species of *Aponogeton* is recommended to those aquarists who do not want to occupy themselves with special cultivation of aquarium plants. Even the multiple hybrids of Asiatic species of *Aponogeton* are fertile and in good conditions develop seeds capable of germinating.

APONOGETON CRISPUS Thunb.

A. crispus is native to Ceylon, where it is found in rivers, lakes, and pools from sea level to 1000 to 2300 meters. Most plants in our aquariums identified as *A. crispus* are actually hybrids that were produced in nature or under artificial conditions. A genuine *A. crispus* is distinguishable by its leaves, which are always red or reddish and never float on the surface.

Plants with leaves of a shape similar to those of this species except that they are of uniform green color are hybrids (usually *A. crispus* X *A. natans*). *A. crispus* has an oblong horizontal rhizome up to 25 mm thick from which only submersed leaves develop. The young leaves are usually reddish, seldom light green. The basic coloration of older leaves is always brown-green to purple. The petiole is much shorter than the blade. The form of the blade is very variable; strap-like, about 25 mm wide and up to 25 to 30 cm long, or elliptical up to 50 mm wide and 20 to 25 cm long. Isolated areas among nerves are usually unevenly colored; some are transparent, so that the whole surface looks like a design in mosaic. Blade margins are thickly curled. The floral stalks are 50 to 80 cm long (a single ear 15 to 17.5 cm long); flowers are white or light violet. Relatively large seeds germinate immediately after ripening.

A. crispus requires a bright tank and prefers an illumination coming from above. Seeds are easily obtained from imported tubercles. In the winter cultivated plants should be left in water at about 59° F (15° C). Under these conditions they may lose all their leaves, but as soon as the temperature is raised at the beginning of spring the growth will be resumed; plants will develop well and be able to produce seeds.

The plant can be maintained under normal aquarium conditions, tolerates old water, and requires a medium rich planting medium without lime.

APONOGETON ECHINATUS Roxb. (Ill. 205, 210)

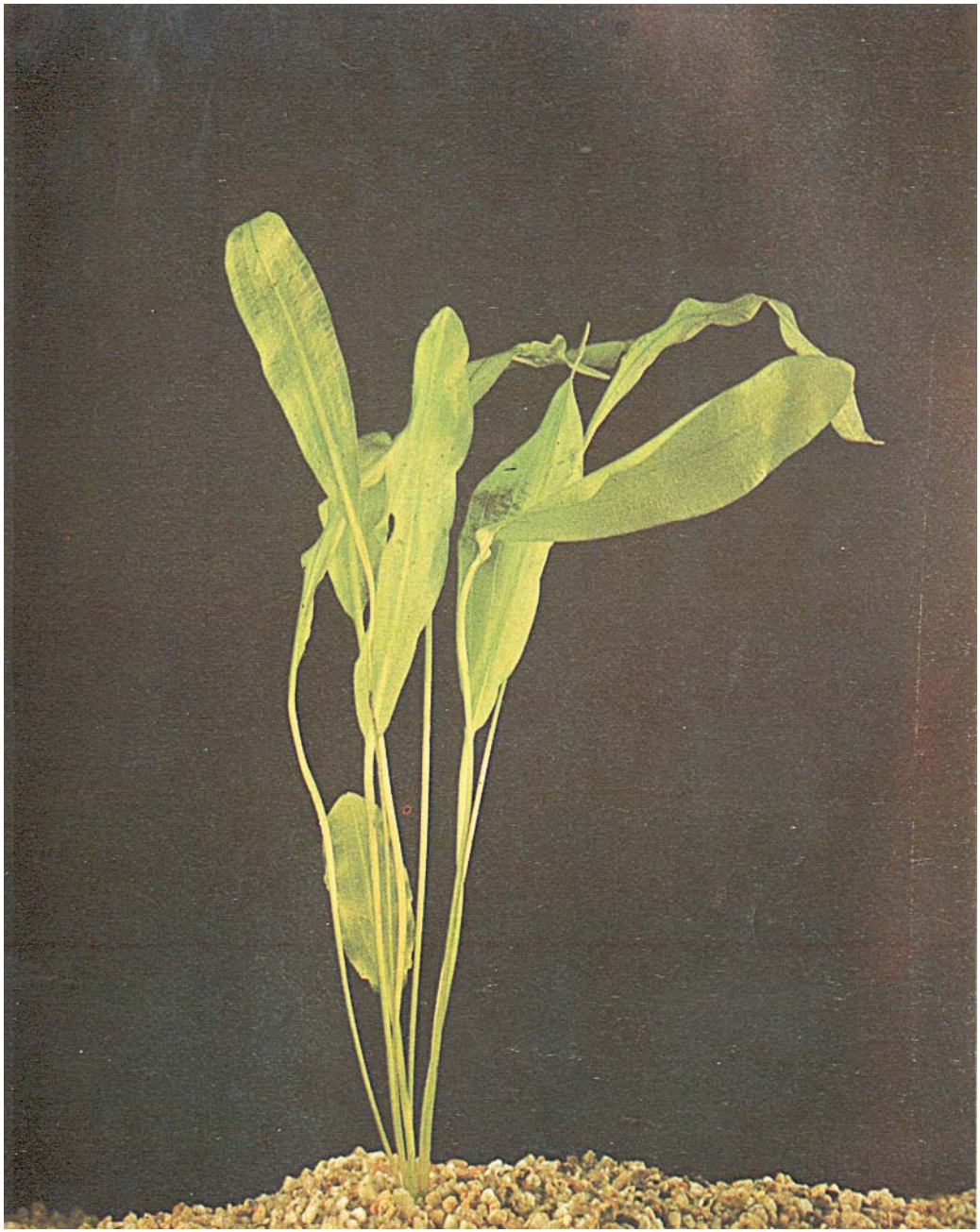
In southern and central India this species grows in large quantities in lakes and ponds between sea level and 1300 meters. It flowers throughout the year. *A. echinatus* was known under the names *A. natans* and *A. undulatus*. *Aponogeton natans* (L.) Engler et Krause is not cultivated in our aquariums. It has submersed leaves up to 5 to 7.5 cm long and 15 mm wide and forms mainly floating leaves which are not suitable for aquariums. *Aponogeton undulatus* Roxb. is the most widely distributed viviparous species



Ripe fruit on the inflorescence of *Aponogeton madagascariensis*. Photo by T.J. Horeman.



Close-up view of the leaf structure and seedling of *Aponogeton madagascariensis*. Photo by T.J. Horeman.



Aponogeton echinatus.

and is known in our aquariums under the name (synonym) *A. stachyosporus* De Wit.

The rhizome (tuber) of *A echinatus* is ovoid, 25 to 50 mm in diameter. Submersed leaves are variable, on long or short petioles; the blade is fragile, transparent, 15 to 40 cm long and 50 to 65 mm wide, with moderately undulate margins. The base is cuneate or truncate, the top is usually rounded. The floating leaves are oval, sometimes narrowed at the top, 20 cm long and 20 to 40 mm wide. The inflorescence is on a single spike; it has minute flowers that are white, mostly bluish, or light purple. In good conditions one plant can develop up to twenty floral stalks in a year. Fruits (10 to 15 mm long) germinate instantaneously.

This species is very variable; with the imported plants we find forms with submersed leaves on long petioles and with many floating blades, or forming numerous decorative submersed leaves on short petioles and without any floating blades. The last mentioned form is suitable for indoor aquariums.

A. echinatus is best cultivated in older tanks where the bottom is enriched with detritus. The soil should not contain lime, and the water should not be too hard. This plant is cultivated in half-shade; in this way the development of floating leaves can be avoided.

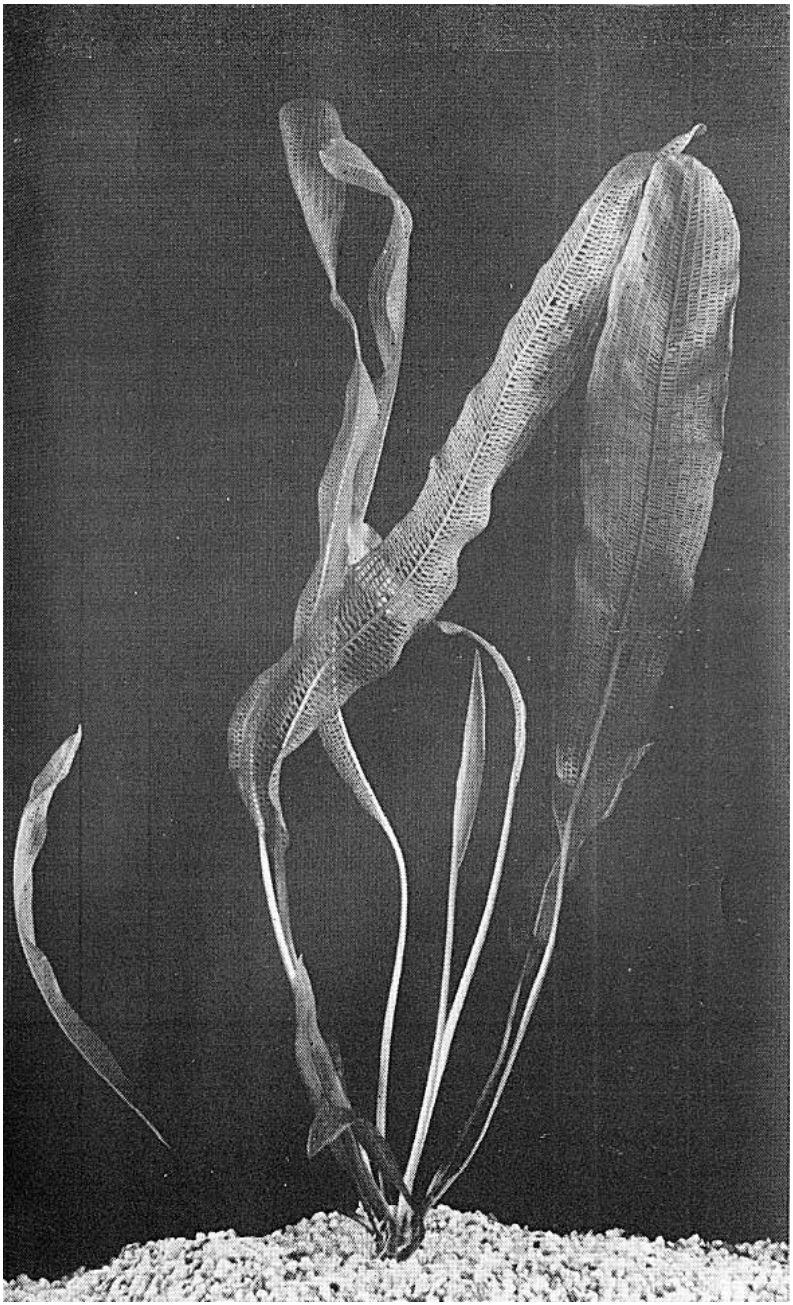
APONOGETON ELONGATUS F. Muller

A. elongatus from Australia resembles *A. echinatus* more than it does *A. crispus*, because the leaf margins are only slightly undulate and are not curled. But unlike the leaves of *A. echinatus* the leaves of *A. elongatus* are 20 to 40 cm long and often colored olive green or red-brown. Besides submersed leaves it develops floating leaves that are usually oval, glossy green, 10 to 15 cm long and 20 to 30 mm wide. After the floating leaves have developed, then the floral stalk is quickly formed. The floral stalk grows up to 12.5 cm in one day. The spike is shorter than in the other Asiatic species (5 to 8 cm), flowers are yellow. In each follicle there are only about four to six seeds (4 mm long).

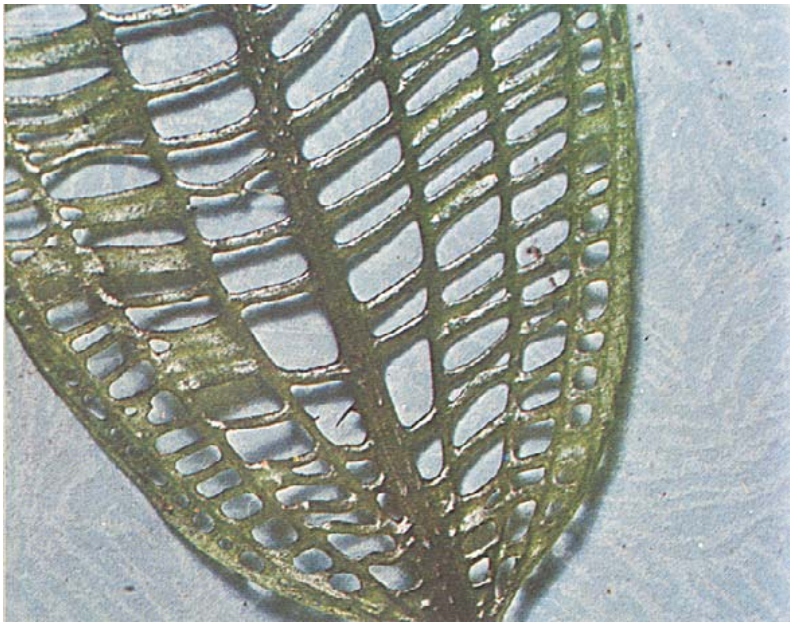
As to the requirements and methods of cultivation, *A. elongatus* resembles *A. crispus;* however, it can withstand much lower temperatures (to below 46° F, 8° C) without any harm.

APONOGETON HYBRIDUS Hort.

This name covers a group of *Aponogeton* plants forming the great majority of aquarium representatives of this genus. This group includes the plants which have arisen through inadvertent crossings among the original species cultivated together in nur-



Aponogeton madagascariensis.



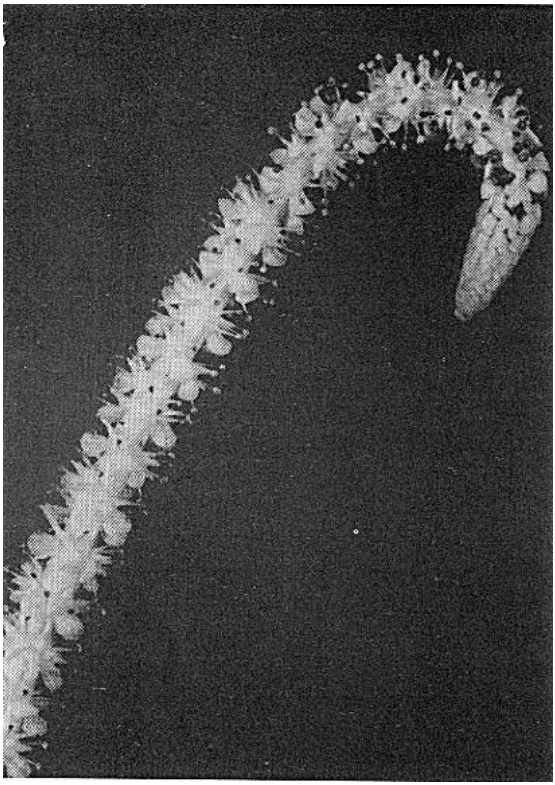
Enlarged section of a leaf of *Aponogeton madagascariensis*. Photo by T.J. Horeman.

Aponogeton rigidifolius. Photo by T.J. Horeman.





Aponogeton ulvaceus from Madagascar showing the characteristic twin inflorescence. Photo by T.J. Horeman.



Enlarged distal end of the spike inflorescence of *Aponogeton echinatus*.

series and in the tanks of aquarists. The original species are *A. crispus, A. echinatus* and *A. natans.*

As stated earlier, these species from natural environments are rather exacting and do not thrive well in aquariums. A natural law of biology prevails here, namely "hybrid vigor." Some of the hybrids are more resistant to adverse external conditions than either of the parent plants; less resistant hybrids died off while the more resistant plants developed and were further propagated. In this manner, i.e., by natural selection, *Aponogeton* spp. have arisen that are fully adapted to aquarium conditions and are now ideal for community tanks. They have no special requirements with regard to the composition of the substratum, water, or light and do not require a resting period. They usually flower all year round, independently of the season, and if the conditions are good they produce plenty of fertile seeds.

Because these hybrids are propagated further by seeds and continue to hybridize, several forms exist. Where a definite selection has been made, plants have been improved and possess special properties derived from all the original natural species. They have leaves 30 to 40 cm long which are probably inherited from *A. crispus* or *A. natans*, leaf margins which are only moderately undulate (from *A. echinatus*), and flowers which are generally blue or light purple (from *A. natans*).

In general there are two groups of hybrids:

1. *A. crispus X A. echinatus*. These plants usually have a long leaf, winding under the surface of the water (after *A. crispus*). The leaf margin is only moderately undulate (after *A. echinatus*). They are ideal plants for the aquarium. Flowers are generally white. Floating leaves are rarely formed.

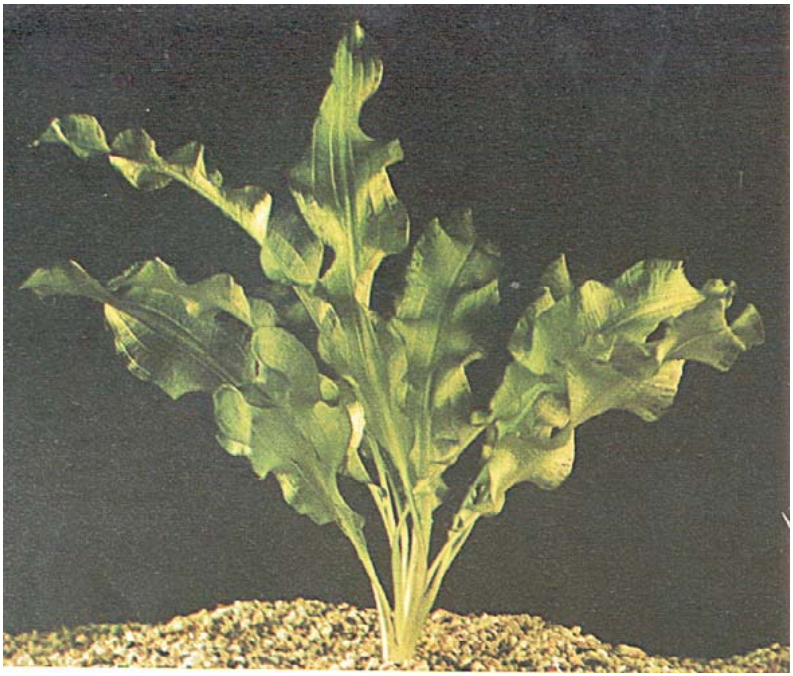
2. (a) *A. crispus X A. natans*, (b) *A. echinatus X A. natans*, and (c) multiple hybrids such as (*A. crispus X A. echinatus*) *X A. natans*. In general it can be said that this second group is less suitable for the aquarium. The submersed leaves keep the characteristics of *A. crispus* and *A. echinatus*, i.e., a long and moderately undulate leaf, but in good light they form floating leaves which are usually undesirable in aquariums. Flowers are mostly blue or purple.

All hybrids of these Asiatic species are fertile and multiply well if the steps presented in the introductory section to this family are followed.

APONOGETON MADAGASCARIENSIS (Mirbel) van Bruggen
Syn: *A. fenestralis* (Poir.) Hook.
(Madagascar Lace Plant) (Ill. 193, 204, 207, 208)

Aquarium literature usually mentions three species of *Aponogeton* from Madagascar which are noted for lace-like leaves formed only by the veins. These are *A. fenestralis* (Poir.) Hook., *A. henkelianus* (Falk.) Baum., and *A. bernierianus* (Descaisne) Hook. It seems that the specific differences are insignificant and that at least two of these plants (*A. fenestralis* and *A. henkelianus*) belong to the species *A. madagascariensis*. *A. bernierianus* does not have fenestrate leaves.

The rhizome is cylindrical, ovate or round, 2.5 to 10 cm long. Leaves measure up to 40 cm long; the leaf blades are oval elliptical, somewhat blunt or moderately acute at the apex, obtuse at the base, sometimes slightly cordately lobed. Blade is 10 to 20 cm long and 25 to 75 mm wide. The interstices between the cross veins are not filled with tissue, and the whole blade is lace-like; this charac-



Aponogeton ulvaceus.

Aglaonema, cultivated under water.

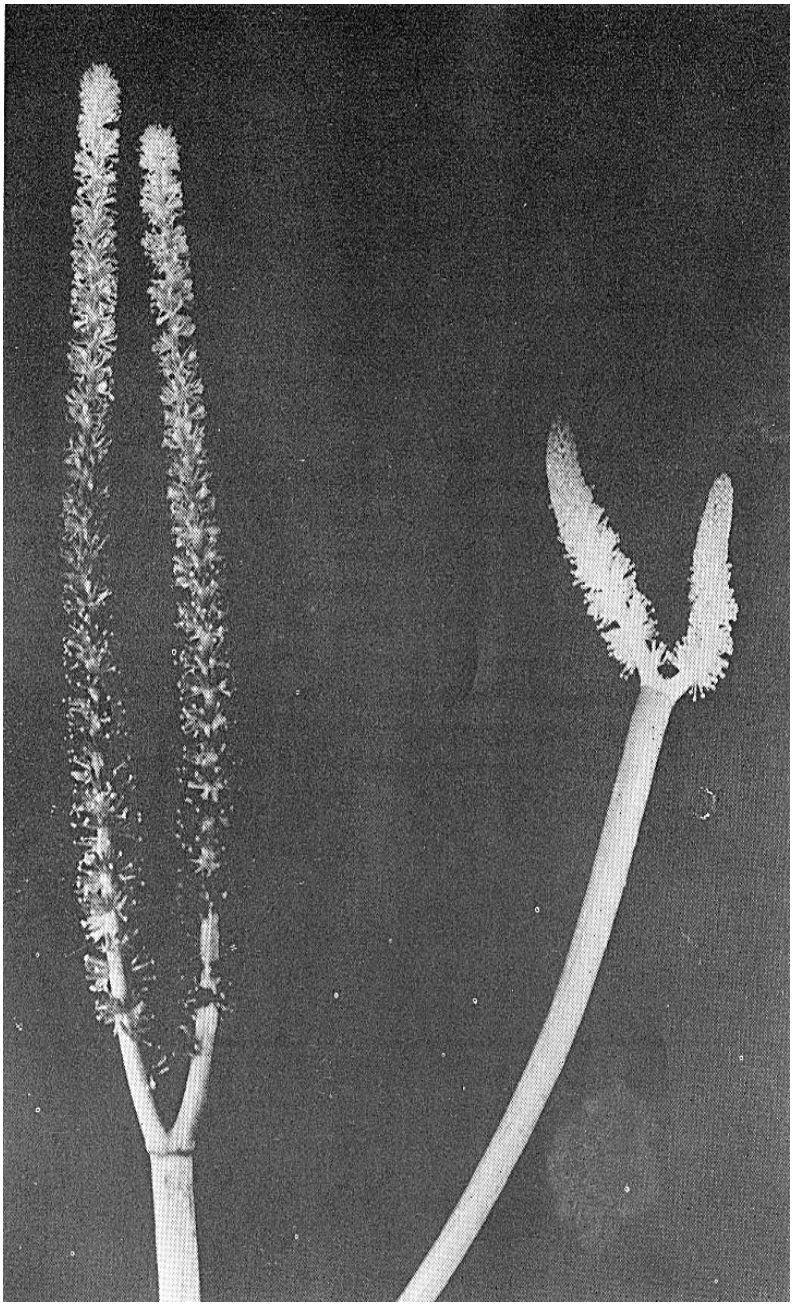




Echinodorus osiris.

New plants are forming on the floral stalk of this *Echinodorus osiris* plant.





Inflorescence of *Aponogeton ulvaceus*. As many as five spikes can develop in this species of *Aponogeton*.

teristic is rarely absent. The white or yellowish inflorescence consists of two to five spikes. After fertilization the flowers turn to pink to red-purple.

This species requires frequent change of water. It can be used in the tank for a single vegetation period. For this purpose only those plants obtained from well developed tubercles are used. They live in the tank for one season and then die off.

To cultivate *A. madagascariensis*, one should put the plants in an isolated tank of a small capacity (7 to 12 gallons, 30 to 50 liters), with rinsed (not properly washed) sand, a medium amount of loam, and a very small quantity of calcium and magnesium salts. It should be located in a bright place, but out of direct sunlight. A part of the water (one-third at least) is changed not less than once a month in winter and every week or two in summer. No new rainwater is used. Under these conditions *A. madagascariensis* flowers well in some years and produces fertile seeds.

Recently two forms have been regularly imported: one has a long, broad leaf (25 to 50 mm) and is sold as *A. henkelianus*; the second has a much broader leaf (5 to 10 cm), the top usually blunt, and is sold as *A. fenestralis*. The narrow-leaved form is much more resistant and does not require a change of water. It flowers and reproduces easily. The seeds are very small (hardly 2 mm long) and the seedlings are difficult to cultivate.

APONOGETON RIGIDIFOLIUS van Bruggen (Ill. 208)

The rhizome of this species from Ceylon is different from that of other aponogetons. It is cylindrical, horizontal, 1 cm thick and 15 to 20 cm long, and creeping. Young plants arise from the rhizome; five to ten plants can develop from one rhizome.

The leaves are submersed and the petiole is usually distinctly shorter than the blades, which are leather-like, firm, 20 to 60 cm long and 25 to 40 mm wide, with flat or distinctly undulate margins. The color of the leaves is variable; some are dark dull green, others are dark red-brown. The midrib is distinct, wide with three to four parallel nerves on each side. The leaf is narrowly cuneate on both sides and usually blunt at the top.

The inflorescence is 50 to 90 cm long; the unique spike is usually 10 to 15 cm long, with minute white flowers. Fruits are 5 to 12 mm.

In nature *A. rigidifolius* grows in deep water (10 to 50 cm), with temperatures of 68° to 77° F (20° to 25° C), and a 7.2 pH in the sandy soil.



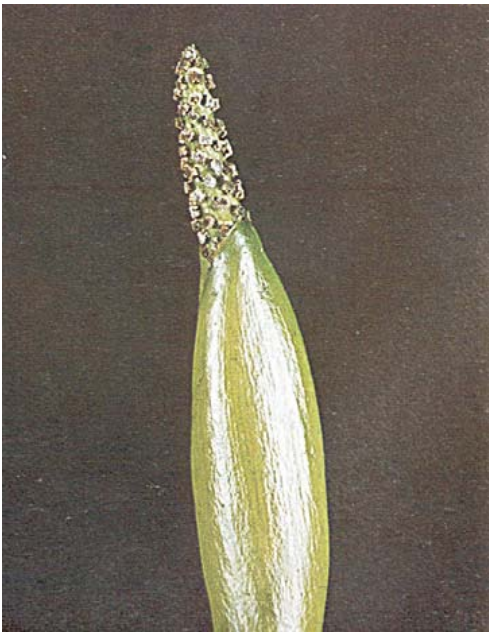
Inflorescence of *Anubias afzelii*.

Anubias afzelii.





Anubias congensis.



Inflorescence of *Anubias congensis.*

Very suitable for the aquarium, it does not form floating leaves; the submersed leaves are very firm and rigid. The brown-red leaves are very attractive. Propagation from the rhizome buds is easy, i.e., young plants can be obtained vegetatively. This plant rarely flowers in the aquarium. As with the other common *Aponogeton* species, propagation by seeds is not so simple.

APONOGETON ULVACEUS Baker (Ill. 75, 209, 212, 214)

A. ulvaceus originates from Madagascar. It has a globular tubercle (up to 30 mm in diameter). The blades have a short or a long petiole, the base tapering gradually. They are light green, almost translucent; oblong, rounded at the upper end; 20 to 35 cm long and 40 to 80 mm wide, with moderately undulate margins. Well-developed leaves are spirally coiled.

The flowers are yellow, the inflorescence with two to five spikes. This species is propagated by seeds produced usually by plants which have been given a minimum of two to three months of dormancy at temperatures of 46° to 50° F (8° to 10° C). Such plants drop their leaves and only the tubercles remain; in the beginning of spring (after a rise in temperature) the tubercles develop leaves (up to 25 cm long) within ten to fifteen days. They begin flowering in April. For the parent plants, the temperature is decreased as early as September—from September to November at 54° to 59° F (12° to 15° C), then down to 46° to 50° F (8° to 10° C) in order to prevent their blossoming a second time, which would occur about fourteen days after the autumnal equinox (i.e., by the end of September in the Northern Hemisphere). The seeds from the autumn flowers do not usually mature; the plants use up the food supply before the winter period.

This is one of the most beautiful aquarium plants, although it is difficult to propagate. Its ordinary cultivation is not exacting, but if the plant is kept at a temperature of about 68° F (20° C) it stops growing and may die.

APONOGETON UNDULATUS Roxb.

Syn: *A. stachyosporus* de Wit

This species from Malaya has some patches in the leaves filled only by clear tissue; in other places it is light to dark green, giving the appearance of a mosaic. It is a very decorative plant. The leaves reach a length of 40 cm and a width of 40 mm. The leaf margins are undulate to curled; floating leaves are broad and oval, cordately lobed at the base.

A. undulatus is an unexacting plant; it can withstand even water that is rich in organic substances (i.e., it can be cultivated in aquariums with many fish), but it requires adequate light.

A. undulatus is a viviparous species; on the floral stalk, instead of flowers, globular tubercles usually arise on which leaves, roots and branches grow, and young plants develop at the tip of these tubercles. On each inflorescence up to twelve new plants arise and a single plant develops five to ten floral stalks during a season.

Key to Aponogeton Species

1a Leaf blade consisting only of veins, having a gauze-like appearance . . . . . *A. madagascariensis*
1b Leaf blade fully formed, all tissues present 2
2a Rhizome horizontal, leaves leather-like . . . . . *A. rigidifolius*
2b Rhizome rounded or absent, leaves membranous 3
3a Inflorescence compound from 2 or more spikes . . . . *A. ulvaceus*
3b Inflorescence simple, formed by unique spike 4
4a Inflorescence yellow . . . . . *A. elongatus*
4b Inflorescence white, bluish or violet 5
5a Leaves densely curled, usually reddish, plants without floating leaves . . . . . *A. crispus*
5b Leaves not curled, at most undulate, floating leaves present . . 6
6a Leaf blade with vari-colored tissue between the veins, new plants arise on the floral stalk . . . . . *A. undulatus*
6b Leaf blades unicolor, without new plants on the stalk 7
7a Mature fruits elongated in sharp, long beaks . . . . . *A. echinatus*
7b Mature fruits blunt or the beak is very short . . . . . *A. hybridus*

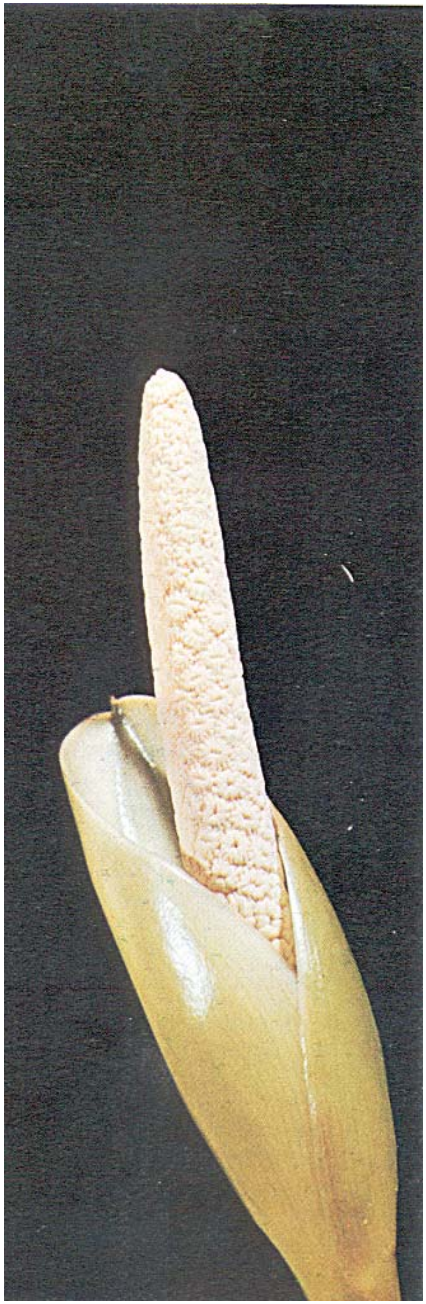
ARACEAE

Most plants of this large family are moisture-loving, marshy or (more rarely) aquatic plants. Many of them are cultivated in greenhouses and as indoor plants. They are of the most varied size, from the size of herbs to the size of bushes and trees.

The leaves are of diverse shapes, simple to compound, differentiated into petiole and blade. Very minute flowers are arranged in a pulpy inflorescence (spadix) surrounded by a large bract that is often differently colored (the spathe).

The seeds of plants of the family Araceae are capable of germinating for only a relatively short time; on account of this, most





Anubias lanceolata (left) and its inflorescence (right).



Anubias nana. Photo by Dr. D. Terver.

species are limited to small areas, and most are propagated either by the formation of root runners or by the division of the rhizome.

Most members of the family are tropical and subtropical plants; only a few penetrate into the temperate zone. The habitat of many genera is strictly limited either to the New or Old World. Exceptions are, for example, the floating *Pistia*, *Arisaema*, and some other genera. The warm areas of the Old World, mainly Malaya and tropical Africa, are richer in members of the Araceae than tropical and subtropical America. Most New World species grow as forest plants at the foot of the Andes. All together 110 genera containing 1800 species are known.

ACORUS (SWEET FLAG)

This small genus contains only two species.

ACORUS CALAMUS L.

A. calamus comes from Southeast Asia; it has been gradually introduced into Europe by way of the United States. It is not suitable for indoor aquariums.

ACORUS GRAMINEUS Soland (JAPANESE RUSH) (Ill. 223)

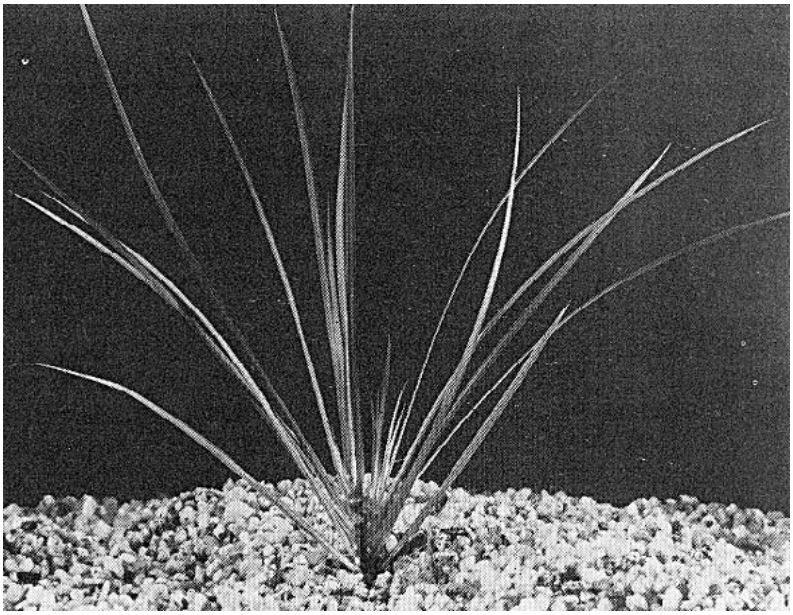
A. gramineus originates in eastern Asia (China, Taiwan, and Japan). The Japanese rush is a marsh plant that can be adapted to life under water.

The rhizome is 10 to 20 mm thick and 10 to 15 cm long, from which ten to fifteen fan-shaped leaves develop. The margins are at first parallel, then prolonged acuminate (resembling the shape of the leaves of the iris (genus *Iris*) . In nature the plant reaches a height of up to 50 cm but in aquariums not more than 15 to 20 cm, with leaves that are 2.5 to 8 mm wide.

A. gramineus var. *pusillus* Engl. is a dwarf form with much shorter leaves. In nature the leaves are up to 10 cm long; in the aquarium they are generally only 50 mm long. The fan of leaves is broad, about the same width as the length of the leaves. This variety is native to China (Japanese dwarf rush).

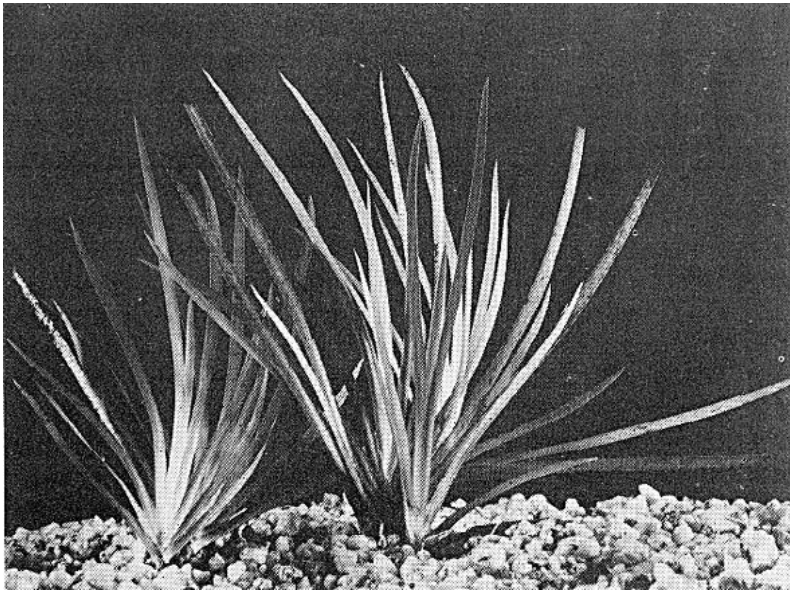
A. gramineus forma *decoratus* Hort., known as the striped Japanese rush, is a horticultural form with yellow-striped leaves. The gay coloring is more distinct in aerial leaves than in plants cultivated under water, in which the variegations sometimes disappear completely. (Ill. 223)

All three forms have the same requirements. If one wishes to propagate them it is best to grow them emersed in dishes or in flowerpots immersed in water; the water should not go higher than 10 to 20 mm above the root collar. If watered regularly they grow



Acorus gramineus.

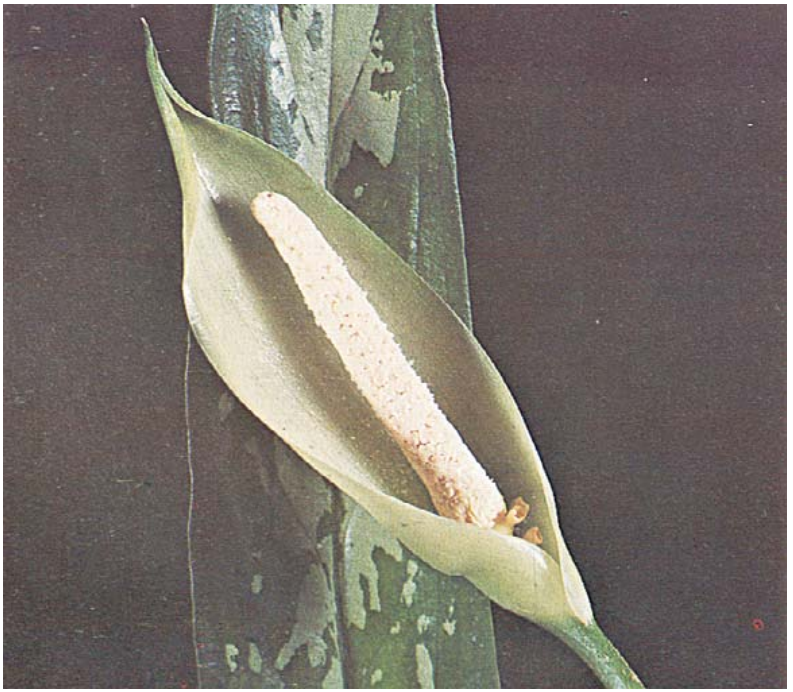
Acorus gramineus var. *pusillus.*





Ripe fruits of *Aglaonema*.

Inflorescence and close-up view of the leaf blade of *Aglaonema*.



well as indoor plants. Within one or two years a long rhizome is formed; this is then taken out of the earth, washed, and left to float freely on the surface of the water either in the aquarium or in an outdoor pond in the summer. Within ten to thirty days between twenty to fifty new plants begin to develop from the dormant buds on the rhizome. As soon as the leaves are about 25 mm long, the rhizome is cut and the leafed cuttings are planted.

Acorus should be planted in rich soil. Growth in the aquarium is very slow; in the first year it usually shows no increase. A comparatively rare plant, *Acorus* is propagated with difficulty but it is a very decorative plant when used in aquariums.

AGLAODORUM GRIFFITHII Schott

A. griffithii is an aquatic plant found in the swamps and rivers of Malaysia, Sumatra, and Borneo. It is a suitable aquarium plant, but still not imported. The rhizome is creeping; leaves are erect, glabrous, fleshy, linear to oblong; petiole is a little longer than the blade. The leaves are 20 to 50 cm long. *Aglaodorum* is closely related to *Aglaonema*.

AGLAONEMA (Ill. 212, 224, 384)

The submersed cultivation of these well-known indoor and greenhouse plants is something rather new. A few representatives of the genus (about 45 species are known) originate in the same area as the genus *Cryptocoryne*, i.e., Malaya and eastern India.

These plants have a strong and firm rhizome from which a very short stalk bearing four to seven leaves develops. The leaf petioles are approximately the same length as the blades; the latter are broadly lanceolate, rather acute at the apex, usually cordate at the base. Leaves are stiff and thick, light to dark green, and crossed by yellow stripes in some species.

We have tested six species of *Aglaonema* (these not having been identified reliably) and found that all of them can be kept all the year without dropping any of their leaves. First they should be planted emersed, then transferred to the aquarium, where they are planted with whole and undamaged roots. Plants obtained by being cut off from the rhizome are set under water only after several weeks of pre-cultivation in the emersed state. After being transferred to submersed conditions the growth normally ceases; the plant loses its resistance, and decay spreads from the wound throughout the whole rhizome.

It is best to transfer the plants into the aquarium with the container in which they have been grown and transplant them into

the aquarium substratum after sometime; they do not tolerate being transplanted into a newly furnished aquarium. Commonly cultivated species can be obtained easily in florist shops. The most common species are: *A. modestum* Schott with green, marbled leaves with silver veins; and *A. treubii* Engl. with dark green leaves decorated with light green and yellow spots. Some hybrids are extremely decorative. They are often labeled as *A. longibracteata*, *A. marmoratum*, or *A. roebelinii*. Their petioles are almost white; leaf blades are irregularly decorated with green, yellow-green, and white spots. All species mentioned reach a height of about 30 to 40 cm and are fit only for large aquariums. The most suitable species is *A. costata*. Its leaves are generally 10 to 15 cm long; the petioles are shorter than the blades, which are egg-shaped, dark green, and trimmed with light yellow round spots (5 to 10 mm diameter) irregularly distributed over the surface. It is one of the most beautiful plants.

ANUBIAS

Anubias is found in tropical West Africa and contains about twelve species growing along shady banks. During the rainy periods they survive under water in the flooded areas for several months and will withstand a permanently submersed environment. They are suitable aquarium plants and are cultivated like *Cryptocoryne* species in a medium-rich substratum and water that is not too acid. Forming a robust rhizome, the plants need sand with a depth of at least 10 to 15 cm. They are shade-loving plants.

The leaves are broadly lanceolate, ovate or elliptical, with an acuminate or rounded tip, tapering below into a petiole which is as long as the blade (though sometimes shorter) and sheathed below. The upper leaf surface is smooth and grass-green; the lower surface is lighter, a yellow-green, with distinct veins. The leaves are very strong and stiff.

Anubias plants are very decorative. They are propagated by rhizome cuttings. A mature rhizome is separated from the parent plant and either divided along the dormant buds and left undisturbed, or the whole rhizome is put in water and divided only after the plantlets are formed. Since it usually takes some years before a fairly long rhizome is obtained and only a few young plants are developed on the rhizome, *Anubias* is very rare.

These plants rarely flower; proper identification is impossible without knowledge of the floral organs, so we are not sure that the plants cultivated in our tanks have been identified correctly.

There are many questions on the nomenclature of the genus *Anubias*, and a skillful revision is needed. Many species are undoubtedly cultivated under incorrect names. Large species reaching a height of 1 meter have usually been regarded as *A. lanceolatus* or *A. congensis*—most probably they belong to *A. heterophyllae*. Seedlings (one to three years old) are suitable for aquariums; mature plants are too large for indoor aquariums.

ANUBIAS BARTERI Engler
Syn: *Amauriella hastifolia* Hepper

A. barteri from Sierra Leone is one of the few species growing regularly submersed in nature. In contrast to other species it has arrow-shaped leaves—some authors assign it to the genus *Amauriella*. Leaves reach up to 20 to 25 cm in length. The arrow-shaped blades are triangular; at the base they are prolonged into pointed lobes.

ANUBIAS AFZELII Schott (Ill. 216)

This medium-size plant occurs in nature mainly submersed; thus it is suitable for aquariums. It differs from other species by its undulate margins. Growing to a height of 20 to 25 cm, *A. afzelii* is also suitable for medium ponds. The petioles are green to reddish. The blade is as long as the petiole, elliptical, and dark green with very dark nerves. It develops very well in the emersed condition but remains small under water. We prefer to cultivate *A. afzelii* in terrariums, using only well-developed plants.

ANUBIAS CONGENSIS N.E. Brown (Ill. 42, 217)

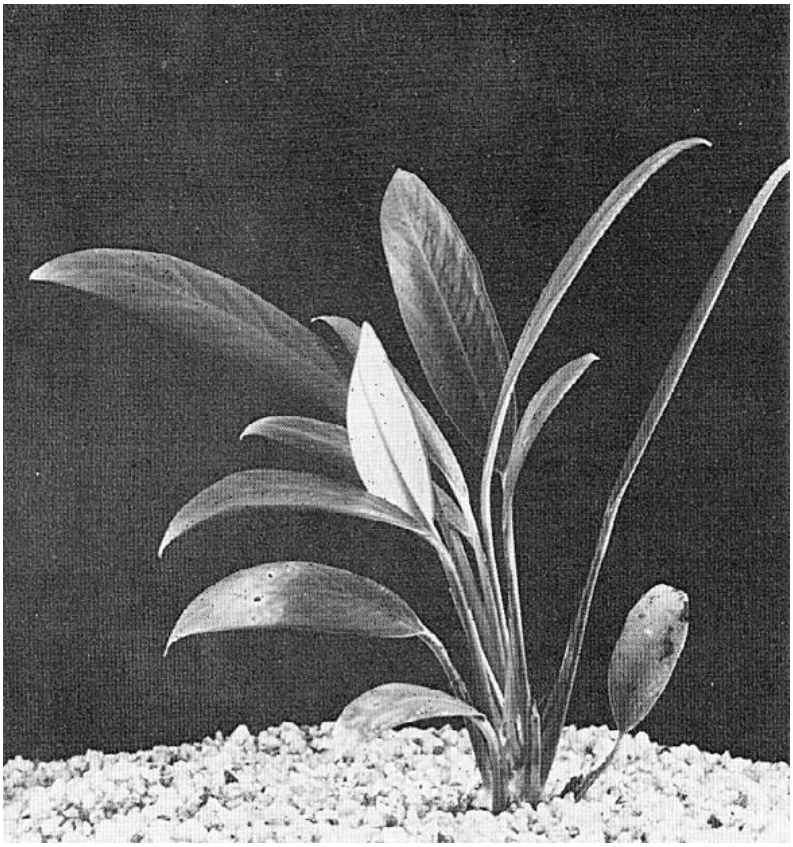
This species from the Congo and Guinea has leaves reaching a length of 25 to 30 cm. The blades are broad, egg-shaped, leatherlike, and blunt at the tip. The veins are usually deepened, broadest in the upper third. *A. congensis* is a very interesting species but is little known in the aquarium.

ANUBIAS LANCEOLATA Schott (Ill. 220)

A. lanceolata is found in Nigeria, the Cameroons, and Gabon. It is the most cultivated medium-size species. The leaves (20 to 30 cm long) have petioles usually shorter than the narrow lance-shaped blades (maximum width 50 mm, 15 to 20 cm long). They are sparkling green with dark nerves; the blade is evenly narrowed on both sides and pointed at the tip.

ANUBIAS NANA Engler (Ill. 221, 228)

A. nana from the Cameroons is the smallest *Anubias*, measuring only 5 to 10 cm in height. The leaf blades are narrowly ellipti-



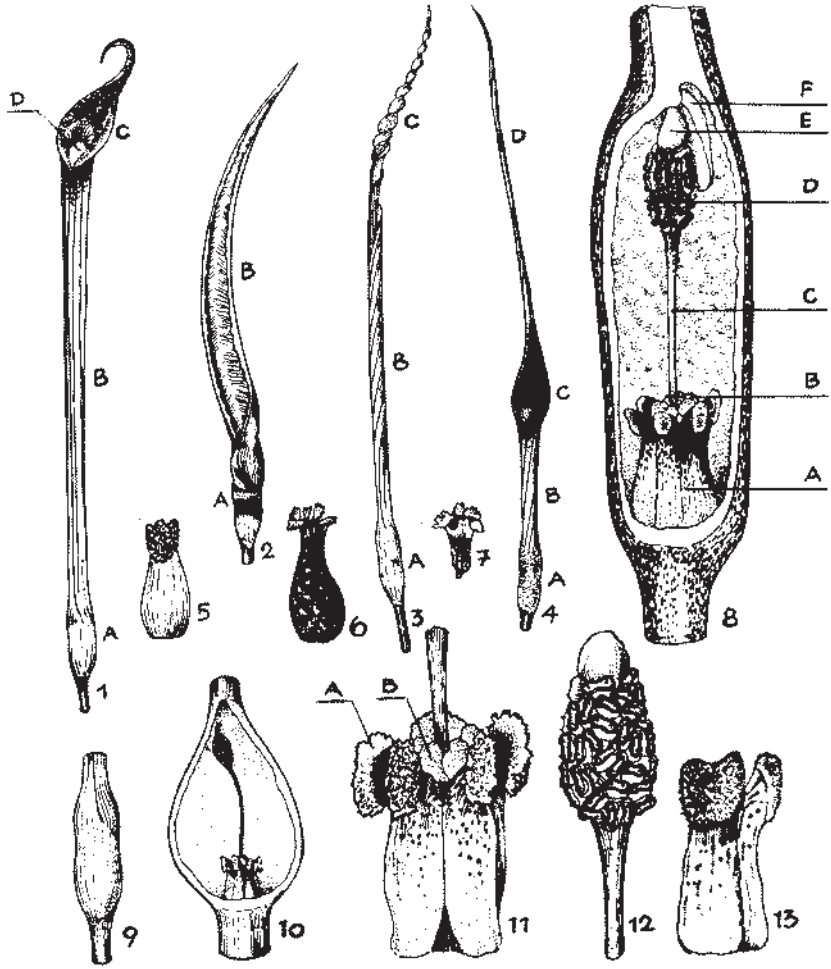
Anubias nana.

cal to lance-shaped, 60 mm long and 20 to 30 mm wide. It is the only *Anubias* appropriate for small aquariums or for planting in the foreground of medium-size tanks.

CRYPTOCORYNE

The genus *Cryptocoryne*, with the genera *Aponogeton* and *Echinodorus*, represents the most important and most popular group of aquarium plants. All cryptocorynes come from tropical Asia.

Up to the present time about sixty species from the Indo-Malayan region have been described. They are found in the area between India, the Malayan peninsula and southwestern China; a



Morphological characters of the inflorescences of *Cryptocoryne*: 1. Inflorescence with a straight tube and horizontal throat (*C. cordata*). A = the kettle; B = the tube; C = limb of inflorescence; D = throat. — 2. Inflorescence without the tube (*C. spiralis*). A = kettle; B = limb. — 3. Inflorescence with twisted tube and limb (*C. retrospiralis*). A = kettle; B = tube; C = limb. — 4. Inflorescence with long caudicle (*C. johorensis*). A = kettle; B = tube; C = limb; D = caudicle. — 5. Pistil of *C. evae* with twice incised and trilobate stigma. — 6. Pistil of *C. gomezii* with horizontal stigma. — 7. Forkedly dentate aromatic corp of *C. crudassiana*. — 8. Kettle. A = pistils; B = aromatic corps; C = lower sterile part of spadix; D = fertile part of spadix with stamens; E = terminal sterile part of spadix; F = valve. — 9. A kettle constricted in the middle (*C. balansae*). — 10. Kettle not constricted (*C. bertelihansenii*). — 11. Female flowers—A = stigma; B = aromatic corps. — 12. Male flowers. — 13. Pistils of *C. hejnyi* with bilobate stigmas.

great number come from the Asiatic islands (Ceylon, Philippines, Indonesian Archipelago).

Cryptocorynes are aquatic or amphibious marsh-dwelling (rarely terrestrial) plants with a very small range of variability of living forms in both the submersed and terrestrial conditions. The petiole and the blade of the leaves are usually distinctly different. Blades may be cordate, elliptical, lanceolate or ribbon-shaped, membranous or leather-like, entire or finely dentate on the margins, smooth or crispate to undulate, and in some species they are alveolate to distinctly "blistered."

Species growing in fast-running torrents have leaves adapted to withstand the current, floating on the surface of the water or under it. Petioles are always sheathed at the base. The petiole and blade lengths in emersed forms remain constant, while in the submersed specimens the length of the petioles varies according to the depth of the water and to the intensity of the light.

Some species have green leaves, and others have distinctly colored leaf blades. The upper surface of the blades is brown-green or olive, sometimes with horizontal or vertical red-brown stripes. The dorsal side of the blades of specimens having green leaves is usually lighter, yellow-green. In species with variegated leaves the dorsal side is olive brown, light to dark red or deep purple. This coloration is not a constant character; it varies according to the light. The red color becomes more intense when the plants grow in deep shade, while the green color predominates in those plants developing with plenty of light.

The root is usually straight, often as long as the leaves or longer, and slightly branched. New plants arise vegetatively from dormant buds on the short upright rhizome of the main root. In some species there are rhizome runners on which new plants are formed at intervals of 1 to 10 cm. One of these methods of vegetative reproduction is typical for some species; others utilize both methods mentioned above. Depending on the prevailing circumstance numerous growths arise from a large number of individual plants, or a single mother plant spreads far and wide by runners, resulting in the establishment of a large colony of a monocultural character.

The inflorescence is very important for the determination of the species. The inflorescence is called a spathe, at the base of which an ovate pear-shaped kettle is situated. The kettle is joined to the tube, the terminal opening of which is called the throat. The upper part of the inflorescence is markedly colored and is called the limb.

Vegetative propagation predominates in plants found both in nature and under cultivation. The fruits of many species collected have not yet been ascertained, and it seems that these species propagate only vegetatively. Therefore many local forms have evolved, giving rise to the predominance of endemic species within the genus *Cryptocoryne*.

Most cryptocorynes are adapted to life in situations with insufficient light. In well lighted places they are not able to resist competition from other plants, their root absorption being inadequate. They occur only in the most deeply shaded places of the jungle in tropical Asia, at places without other low vegetation. It is rare to find two or more species of *Cryptocoryne* living together. One-plant cultures of a single species developed vegetatively, occupying shallow brooks with a stony ground covered with sand, are typical. In deeper waters they grow in the middle of streams, occurring in a submersed form passing over to a littoral amphibious form, rather rarely into a coastal type of vegetation. They are also found in narrow streams, often with very fast-running waters about 3 to 7 meters wide, completely shaded by thick tree vegetation. The genus *Barclaya* is very seldom seen in association with *Cryptocoryne* species. In fast-running streams with a stony to rocky bed often covered by sand *C. balansae* grows, also *C. tonkinensis* and *C. crispatula*. The water is soft, with the pH nearing the neutral value. One group of species contains those evidently preferring the exposure of the roots to air or oxygen (aerobiotic), whereas other species (such as *C. cordata, C. griffithii*, etc.) tolerate the non-exposure of the roots (anaerobiotic) well and occur both in running streams and in still waters of marshes with a thicker layer of mud.

The popular species of *Cryptocoryne* are cultivated at temperatures of about 68° to 77° F (20° to 25° C), which can be maintained all year long. Many fishes have the same temperature requirements, and this is another reason for the suitability of cryptocorynes for the aquarium. Marsh species (*C. becketii, C. nevillii, C. willisii*) growing in nature above water during a certain period are the most resistant to a cool environment, whereas the typically submersed species (*C. cordata, C. longicauda*) are sensitive to low tempeatures (below 64° F, 18° C).

Tanks with cryptocorynes should not be exposed to direct sunlight. When an aquarium is placed near the window, a position facing the north or the northeast will be most suitable. Cryptocorynes do well in an unchanging light. Most species flower, provided they are cultivated in the emersed state only.

Common species are propagated relatively quickly and during a single growing period can overcrowd a tank. Newly imported species are propagated slowly and often form only one single runner in the whole year. A resting period is required, so they should not be transplanted. Root runners are formed, but often not before one or two years after transplanting.

Cryptocorynes are ideal aquarium plants, being very varied as to form and color. Because cryptocorynes acidify the water, they form a favorable medium for the survival and spawning of many popular fish species. Certainly some species are propagated only with difficulty, but well-developed specimens are maintained easily. Only the more advanced aquarists succeed in cultivating cryptocorynes, because these plants can not tolerate any fluctuation in the temperature and require more care and knowledge than plants like *Vallisneria*, *Sagittaria*, and others.

Scientists have great difficulty with the genus *Cryptocoryne*. The various species can be reliably distinguished only by their inflorescences and many species flower rarely not only under artificial conditions but also in nature. The flowers of some species are not known at all. This is the primary reason for the incorrect determinations and incorrect nomenclature of many cryptocorynes in the existing literature. The genus *Cryptocoryne* has been revised recently by the senior author. As a consequence there are some new names in the following pages describing individual species. Incorrect or invalid names are mentioned following the valid ones. Only those *Cryptocoryne* species which have been imported and grown in aquariums are included. For those interested, information about other species can be found in the following technical literature:

Rataj, K. 1975. Revision of the genus *Cryptocoryne* Fischer. Academia, Praha, 174 pages.

Wit, H.C.D. 1970. A key to the species of *Cryptocoryne*. Belmontiana, p. 257-280.

Wit, H.C.D. 1971. *Cryptocoryne*. Aquariumplanzen, Stuttgart, p. 257-280.

CRYPTOCORYNE AFFINIS N.E. Brown (Ill. 41)
Syn: *C. haerteliniana* Jacobs

C. affinis is one of the most widely distributed aquarium species from southwestern Malay Peninsula. The petioles are approximately as long as the blades; the whole leaf is 15 to 30 cm long. The upper surface is light glossy dark green with light veins; the

lower surfaces of well developed leaves are purple to violet, although sometimes the under surface is light green or yellow green with pale purple spots. The color of the lower surface is more intense in stronger light.

C. affinis is perhaps the most widespread and most popular *Cryptocoryne*. Given good conditions it grows very quickly; during a single summer it can overcrowd the whole tank. It is very sensitive to calcium and does not do well in alkaline or hard water. When exposed to direct light the leaves collapse and touch the ground and the plant dies. Temperatures below 68° F (20° C) stop the growth of this species.

It should be cultivated in moderately diffused or artificial light. Propagation is by root runners. Flowers are often produced under water; the inflorescence reaches up to 25 cm long, with the spathe (above the orifice) being elongated into a purple-red, spirally coiled blade. *C. affinis* is recommended for aquariums only, not for terrariums.

CRYPTOCORYNE ALBIDA Parker — see *C. korthausae.*

CRYPTOCORYNE APONOGETIFOLIA Merril — see *C. usteriana.*

CRYPTOCORYNE AURICULATA Engler

This species grows in Borneo (Sarawak) and in the Philippines (islands of Palawan and Mindanao).

The leaves (10 to 15 cm long) have ovate blades that are dark brown-green and margins that are sometimes undulate and inconspicuously dentate. The base is abrupt or cordately lobed, and the lower third of the leaf is widest and from there, slowly becoming pointed to the tip. The blade is 5 to 10 cm long and usually 25 mm wide (sometimes with dark transverse stripes).

The inflorescence is about 50 to 75 mm long, on a short peduncle. The kettle (15 mm long) is colorless and translucent, with a tube that is 5 mm long. The ligulate limb is bent forward, smooth inside, red, and lighter in the throat.

C. auriculata is one of the most precious aquarium plants. It grows emersed as well as submersed slowly and is difficult to propagate. It endures hard water and can be cultivated in aquariums without fish, requiring an undisturbed tank with very clean water free of algae and an abundance of organic matter.

A similar plant that has not yet been reported is *C. pygmaea* Merril, hardly reaching half the height of *C. auriculata*; its inflorescence measures a little more than 2.5 cm.

CRYPTOCORYNE AXELRODII Rataj (Ill. 41)

Syn: *C. willisii* Engler ex Baum, *C. undulata* Wendt, *C. pseudobecketii* Hort.

This plant really has had bad nomenclatural luck. It was described twice, in 1909 and 1920, but neither name in the two descriptions can be acknowledged as valid according to the international botanical laws.

C. axelrodii is confined to Ceylon. It links *C. walkeri* to *C. wendtii*. The leaves are 25 cm long and the petioles are approximately of the same length as the blade. The submersed plants are mostly shorter with green-brown to red leaves. The blades are oblong lanceolate, narrowing and nearly meeting at the base (margins are undulated), and 7.5 to 15 cm long and little more than 25 mm wide. Blades of emersed plants are green, with a reddish main nerve; in submersed plants they are mostly red-brown, with dark stripes. The lower leaf surface is lighter, brown-green or pink.

The inflorescence measures a little more than 7.5 cm long. It is twisted above the throat, greenish yellow or ochre yellow-brown, and the margins are slightly dentate. The throat is light green; the collar is brown, trimmed on the lower side by two very thin lines (the upper line whitish, the lower line dark green).

A typically amphibious plant growing better emersed than submersed, *C. axelrodii* flowers only when emersed with a rather low air humidity. It is easy to cultivate in the aquarium; unexacting, endures a great variety of temperature, and needs medium hard water. *C. axelrodii* propagates quickly by means of rootstocks and rhizomes. It belongs, with some forms of *C. wendtii*, to the commonly cultivated species and is the most beautiful cryptocoryne. Its leaves are mainly colored, often very dark, beautifully contrasting with other bright green plants.

CRYPTOCORYNE BALANSAE Gagnepain (Ill. 236)

Syn: *C. longispatha* Merril, *C. somphongsii* Hort.

C. balansae is distributed in Thailand, North Vietnam to Kwangsi Province in China, growing there in shady to poorly sunlit situations, usually in submersed forms, in various depths of slow- or fast-running water. In natural localities the water has 9° DH and a pH of 7, sometimes higher. The bed of the streams where *C. balansae* grows is stony (usually limestone) and the plants are tightly and deeply rooted in the fissures among large stones covered with sand. In water depths of 1 to 2 meters, the leaves are green-brown, floating, and very long (50 to 75 cm). In

average cultivations if emersed *C. balansae* develops well and flowers easily. During the spring months it sometimes develops emersed, nearly upright, long elliptical blades, with hardly any noticeable "blisters"—other emersed leaves being typically bullate.

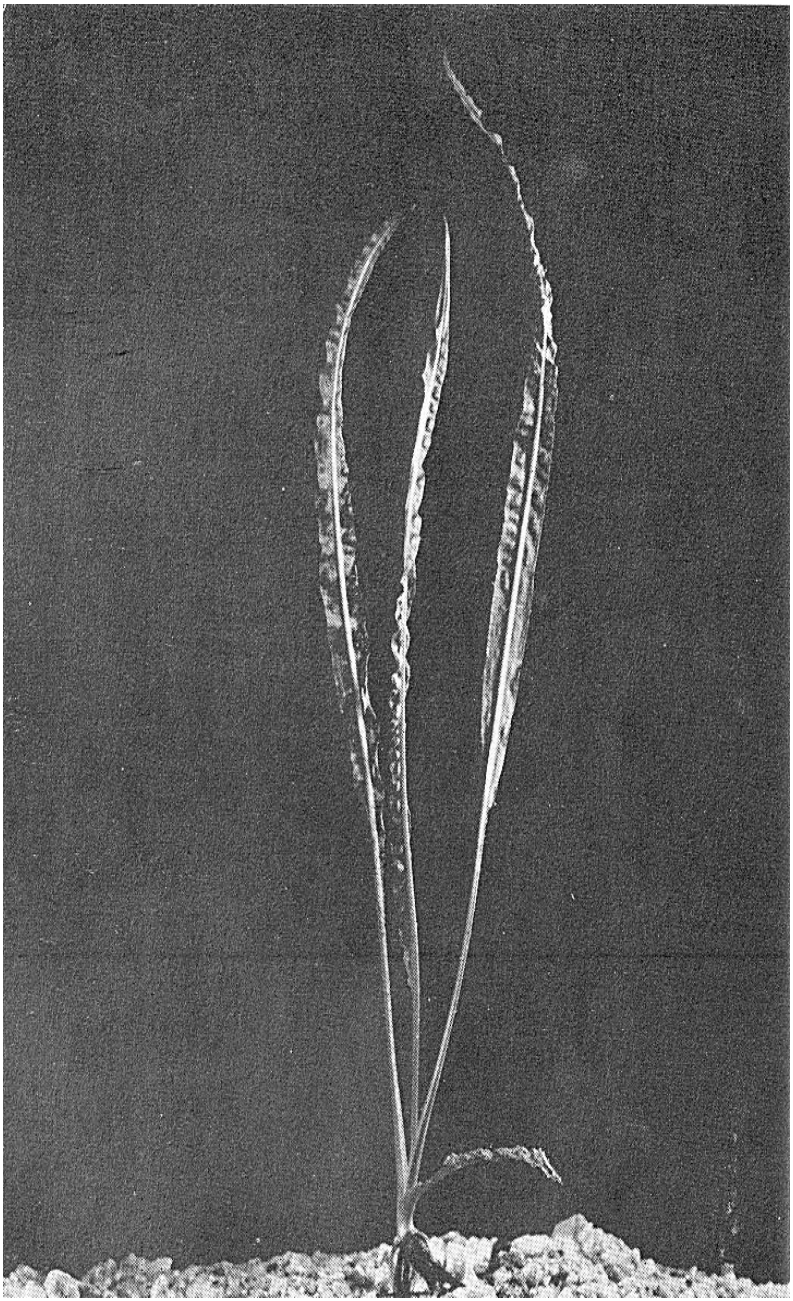
The root is straight, with numerous secondary roots. The leaves (25 to 50 cm long) have petioles usually shorter than the blades. The leaf blades are long, elliptical, sometimes with parallel margins; in the middle both sides are narrowed, along the midrib strikingly bullate, on the margins almost even. Leaves of emersed plants reach a length of 5 to 10 cm; their blades not more than 10 mm wide, as with the submersed form they are green, bullose, rarely even. The smooth, entire blades develop temporarily, mainly during the change from the submersed state to the emersed state. Typical submersed plants have blades measuring 10 to 20 cm long and 10 to 35 mm wide that are olive green or olive brown, while the petioles are often reddish.

The inflorescence is 15 to 25 cm long. The kettle is widest in the lower third of the inflorescence; the upper part is constricted, deep red-brown, covered vertically with purple dots. The length of an almost upright or twisted tube changes according to the depth of the water. The limb (50 mm long) is upright, ligulate with short or long caudicle (up to 35 mm), usually entire in the lower two-thirds of the limb, or only the caudicle is twisted two to three times. The inside wall of the limb is yellow, or yellow-green trimmed with striking wine-red lines of different lengths, shortened in the throat sometimes to dots.

The plant is relatively modest in its requirements for cultivation and is not too sensitive even to direct sunlight, but it can not tolerate low temperatures. It propagates very slowly by rhizome runners, forming not more than two to three individual plants per year. Plants that are several years old can be propagated by cutting off the rhizome on which five to fifteen new ones appear.

CRYPTOCORYNE BOGNERI Rataj

C. bogneri was found in Ceylon and is an important evolutionary link, the discovery of which helps our understanding of the evolution of a species. Previously it was difficult to explain the presence of *C. thwaitesii* in Ceylon, because it completely differs from other *Cryptocoryne* species found in Ceylon. *C. bogneri* explains its presence there, as its leaves resemble the shape of those of *C. thweitesii* and its inflorescence shows a remarkable relationship to that of *C. walkeri*.



Cryptocoryne balansae.

The leaves are about 10 cm long, their petioles brownish and longer than the blades. The blades are elliptical and the base is moderately cordately lobate, while the tip is nearly blunt. They are deep green, brown-green or red-brown, occasionally alveolate, and 50 mm long and 25 to 30 mm wide. Their margins are undulate or crispate, appear dentate, and the texture is leather-like.

The inflorescence is about 75 mm long; the kettle is red-brown, and the tube is only 10 mm long. The limb is ligulate (30-35 mm long), longer than the kettle and the tube together. The outside is reddish; the inside (including the throat) is clear yellow. There is no collar, and the upper part and the margins are warty.

C. bogneri is one of the most decorative species. It grows emersed as well as submersed—there are no records yet of its cultivation in aquariums. There are only a few specimens of this plant existing in artificial cultivation at present.

CRYPTOCORYNE BECKETII Thwaites ex Trimen (Ill. 360)

C. becketii comes from Ceylon and is related to *C. petchii.* The most resistant species among cryptocorynes, it is suitable for all aquarium conditions.

The leaves are 15 to 26 cm long; petioles are olive-brown and longer than the blades, which are oblong, abrupt or shallowly lobate at the base, rarely decurrent. They are widest at the lower third, acuminate to the tip. The upper surface of the leaf is olive brown-green with darker veins, while the lower surface is purple-brown to pink. The lower parts of the margins are usually undulate, and the blade is 75 mm long and 25 mm wide.

The inflorescence is 7.5 to 10 cm long, with a kettle that is 15 to 17 mm long. The tube is upright, pinkish like the kettle. The limb is 30 to 45 mm long; at the base of the dilated part it is usually inconspicuously dentate, brown-yellow or olive-brown. A collar separates the surface of the limb from the purple to chocolate-brown throat.

C. becketii is easy to maintain, enduring even hard water and strong light. It can be propagated rapidly from rhizome runners; after transplanting it soon takes root and grows abundantly within the same year. This is the most suitable *Cryptocoryne* for beginners.

CRYPTOCORYNE BLASSII de Wit — see *C. siamensis*

CRYPTOCORYNE BULLOSA Beccari ex Engl. (Ill. 361, 365)

C. bullosa is better known from imported and cultivated plants than those coming directly from their natural environment.

It occurs probably only in Borneo.

The leaves are 10 to 30 cm long. The petioles are green, the upper parts are sometimes red. The petiole is sheathed almost in its full length with the exception of the upper fourth and is as long as the blades or longer. The blades are oblong-lanceolate, with the tip narrowed, and the base is decurrent, abrupt, or indistinctly lobate. The blade is 5 to 15 cm long and 15 to 30 mm wide, and the whole surface is covered by rows of blisters. The upper surface is green or brown-red, while the lower surface is whitish or pink, but always lighter.

The inflorescence is shorter than the leaves and has a length of about 50 to 75 mm. The kettle has a short peduncle. The tube is upright, not more than half as long as the kettle, colorless or pink with fine purple dots. The ligulate limb is 15 to 20 mm long, purple red, and indistinctly wrinkled. The collar is distinct and rarely indicated.

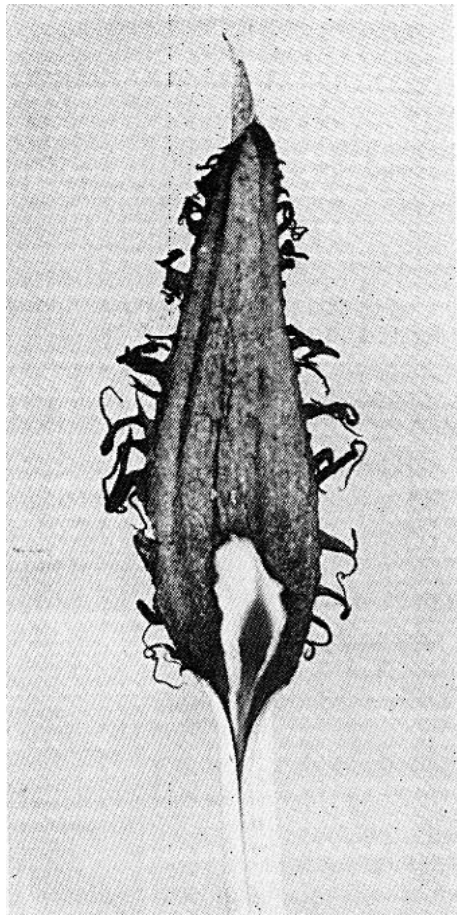
C. bullosa is a typically submersed plant belonging to the most decorative and attractive representatives of the genus. Although known for a relatively long time, it is only recently that an ample supply of plants has become available from natural sources; these plants are now imported. Propagation is very slow. Its cultivation is similar to that of *C. balansae.*

Note: *C. scurrilis* de Wit, a recently described species from Sumatra, is doubtful. Herbarium plants of this species do not bear any characters distinguishing them from *C. bullosa.* Prof. de Wit mentions that *C. scurrilis* differs in the coloring of the limb of the inflorescence, but this cannot be proved from plants deposited in the herbarium. At present it is regarded only as a variety (*C. bullosa* var. *scurrilis*).

CRYPTOCORYNE CILIATA (Roxb.) Fischer ex Wydler

C. ciliata is distributed from the eastern state of India across the coastal areas around the Bengal Gulf to Thailand and Malaysia (both Malay Peninsula and Sarawak) as far as the Indonesian Archipelago (Java, Sumatra, Celebes, Bintan, Moluccas, Siberut) and New Guinea including Papua.

This species has the widest geographical distribution among the cryptocorynes, occurring in large mangrove areas of tropical Asia, where it occupies the solid banks of larger streams on sufficiently lighted situations. A typical terrestrial species, *C. ciliata* occurs rarely in shallow inundated places. The leaves and inflorescences are always emersed. They are found mostly on loamy clay



Limb of the inflorescence of *Cryptocoryne ciliata* with the excrescences distinctly visible.

soils on the coastal plains to a height of 50 meters and extend to a distance of about 50 km inland from brackish water areas into fresh water in thickly wooded areas.

There are two varieties of *C. ciliata*. The basic variety (*ciliata*) is 1.2 meters tall and propagates by long rhizome runners; the second variety (*latifolia*) is only 15 to 25 cm tall and does not propagate by rhizome runners.

CRYPTOCORYNE CILIATA var. *CILIATA* (Ill. 239, 361, 416, 417)

The leaves are 0.5 to 1 meter long, with strong green petioles; the lower third of the petiole is sheathed. Leaf blades are leather-

like, fleshy and thick, dark green, and smooth; the lower surface is somewhat lighter than the upper surface. They are 20 to 35 cm long and 5 to 12.5 cm wide, long or short lanceolate; their bases are abrupt, decurrent, usually cordate. Six to fifteen thin recurved lateral ribs run out from the strong main rib.

The inflorescence is 20 to 37 cm long. The kettle (20 mm long) is constricted in the middle. The tube is straight, not twisted, white-yellow or pink, and the throat is yellow, red spotted, and smooth. The limb is purple-red (rarely pink or olive-yellow-green), vertically wrinkled or smooth, remotely veined, and about 75 mm long and 15 to 20 mm wide. There is a distinct collar at the base. Outstanding excrescences reaching to a length of 5 to 15 mm and branching at the tip or the middle adorn the margins of the limb at intervals of 5 mm. These are purple-red or brown.

This variety propagates vegetatively by rhizome runners, 30 to 40 cm long, on which new rooting plants develop in intervals of 7.5 to 10 cm; thus they can be found occupying several square meters of area on the banks of streams.

CRYPTOCORYNE CILIATA var. *LATIFOLIA* Rataj

The leaves are 12.5 to 20 cm in length, with leather-like cordate or lanceolate blades whose bases are deeply lobed and measure from 5 to 10 cm in length and 25 to 50 mm in width (twice as long as it is wide). A purple-red limb is characteristic of the inflorescence.

Long rhizome runners do not arise with vegetative propagation, but new plants develop either directly on the rhizome from dormant buds or on very short (only 10 to 20 mm long) runners. Numerous tufts of growth gradually develop from several plants.

C. ciliata var. *ciliata* is suitable only for a large paludarium or terrarium, and under favorable conditions this plant reaches a good size even in the aquarium and grows out of the water. Unlike other cryptocorynes, moreover, it requires a good light or indirect sunlight; thus in order to limit its exuberant growth it is cultivated in partial shade on a rather poor substratum. Hard water is tolerated well by it. For the aquarium, var. *latifolia* is the most suitable; it is not too large and submersed conditions are tolerated all year round.

CRYPTOCORYNE CORDATA Griffith (Ill. 416, 420)

Syn: *C. grabowski* Engler, *C. purpurea* Ridley, *C. grandis* Ridley

In comparison with other species, *C. cordata* is distributed over a large geographical area, from southeastern Malay Peninsula

to Borneo and Java. It is a very variable species with regard to the size and color of the leaves and the limb of the spathe. *C. cordata* can exist in the most deeply shaded areas. In this condition, the coloring of the flowers will depend on the intensity of the light. This reality led to a lot of confusion concerning the exact characteristics of *C. cordata.*

Plants growing as emersed forms in shallow water are abundantly leafy, while those found in deep water and shady places often develop only three to four leaves per plant. The leaves are 20 to 40 cm long with green or red-brown petioles which are slight, sheathed at the base, twice as long as the leaves but seldom of the same lengths. The leaf blades are typically cordate, lobate at the base, on the average half as long as wide, rarely of the same length and breadth or more rarely lanceolate, and the base is smooth or remotely alveolate. Both cordate and lanceolate blades can occur simultaneously on a single plant. The upper surface of the blades is deep green, while the lower surface is green, red-brown to intensive red; in a well-lit situation they are greener, when in the shade redder. Blades measure from 7.5 to 12.5 cm in length and 25 to 75 mm in width.

It is typical for *C. cordata* to have inflorescences that are longer than the leaves; the inflorescence is upright and 10 to 50 cm long, usually reaching about 7 to 17.5 cm in submersed plants. Extremely long ones arise in deep water, extending the tube. The kettle is colorless or pinkish; the limb is funnel-shaped with a ligulate base. Including the caudicle (13 to 40 mm long), the limb is 50 to 75 mm long. The tube dilates into a funnel-like shape, so that the throat is wide and occupies usually a third of the surface of the limb, which is most often purple, brown to vermilion red, or dirty yellow, but can also be light yellow or colorless. Our experiments showed that flowers of plants situated in well-lit places are always purple; the same plants when situated in deep shade can have yellow flowers. However, the existence of forms or varieties always flowering yellow cannot be denied.

In nature *C. cordata* is found in places with soft, neutral or slightly acid water that is usually exceptionally clean. These places are flooded occasionally by brown, muddy, and acid water. In its natural habitat *C. cordata* occurs in such deep shade that no other plants can exist, but it has been proved that in emersed artificial cultivation *C. cordata* prefers plenty of light. In the aquarium this species is cultivated in clean washed sand without peat. The sand should be supplied sufficiently with mineralized detritus. For this

reason *C. cordata* can be cultivated successfully only in mature aquariums with crystal-clear water with a perfect biological balance. It does not tolerate fresh water poor in nutrients, so it is not for beginners. *C. cordata* is currently imported but is an exacting species. This plant is very decorative (especially the violet undersides of the leaves), but diffused light is required; in the shade the leaves lose the violet color and turn green on both sides.

CRYPTOCORYNE COSTATA Gagnepain
Syn: *C. hansenii* S.Y. Hu (Ill. 64)

C. costata comes from Thailand; it is a typical species of coastal vegetation rarely descending into the beds of streams. It prefers to grow on sandy ground.

The leaves are 10 to 15 cm long; the leaf blades are lanceolate, 7.5 to 10 cm long and 10 to 15 mm wide, with a large main rib. Their margins are usually entire or undulate (sometimes inconspicuously dentate at the base). Emersed plants have red-brown leaves which are trimmed with vertical red-brown lines on the petioles and blades. Submersed forms have green leaves, but the red-brown lines are present and these are typical for this species. The inflorescence is about 10 cm long. The kettle is dark purple in the upper third, white in the lower two-thirds, with indistinct red dots. The tube (usually twisted two or three times) is yellow-brown and the limb, which is three to five times wider than the tube and nearly upright, is sometimes prolonged into a short caudicle. The inner surface of the limb appears cream-white with numerous small and fine dots.

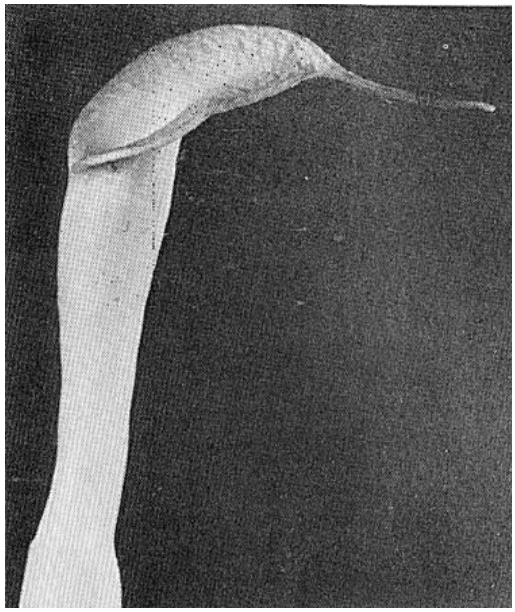
C. costata grows well in the emersed state. Under water it requires the same conditions as other species, but cannot endure great temperature changes. It is very rare and one of the more sensitive species which take root slowly. Both the shape and color of the leaves differ greatly from other *Cryptocoryne* species, so it is a very valuable addition to our hobby. This species is suitable for aquariums, paludariums, and terrariums.

CRYPTOCORYNE DIDERICII de Wit (Ill. 243)

The origin is uncertain, probably Malacca in Malaysia.

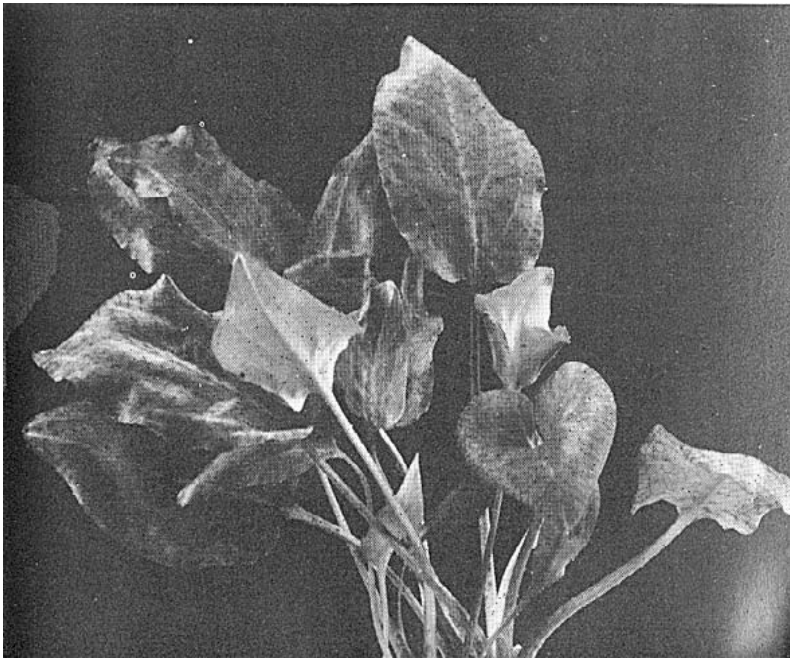
The leaves are 7.5 to 15 cm long; their reddish or green petioles are as long as the leaves or slightly longer and sheathed at the base. The ovate leaf blades, 50 to 75 mm long, are deep green (lower leaf surface is green or brownish), nearly blunt at the tip, and usually lobate at the base.

The inflorescence (about 75 mm long) is shorter than the



Inflorescence of *Cryptocoryne didericii* showing the warty condition of the limb.

Cryptocoryne didericii.



leaves and the peduncle is very short. The kettle as well as the tube are white or pinkish, and the limb (2.5 mm long), which is warty or nearly smooth, has two layers of color (the lower one being yellow, the upper red), so that there are areas of intensive yellow with brown to reddish tinges on the limb. The limb is usually yellow in the middle, pinkish or brown in the lower part on the margins. The uniformly colored bright yellow throat is without a collar. The tip of the limb is elongated; the caudicle is approximately 10 mm long.

C. didericii is cultivated in the same way as *C. cordata.*

CRYPTOCORYNE EVAE Rataj (Ill. 417, 425, 428)

C. evae is one of the most decorative species of *Cryptocoryne.* Its origin is unknown, probably Thailand. Except for *C. ciliata*, it has an inflorescence with the largest limb. *C. evae* is commonly cultivated under the incorrect name of the narrow-bladed *C. blassi.*

The leaves are 40 to 60 cm long, with petioles twice as long as the blades or equally as long, which are green or red-brown. The blades are lanceolate (both sides nearly symmetrically narrowed); their upper surface dark green or olive-brown and very smooth and shiny, while the lower surface is red-brown to violet and also shiny. The blades are 15 to 22.5 cm long and 50 to 75 mm wide.

The inflorescence is 12.5 to 17.5 cm long. The kettle is slightly constricted in the middle, light yellow brown, and covered thickly and irregularly with purple dots while its lower half is purple inside. The throat is funnel-shaped, dilated, and bright yellow. The limb is cordate, 25 to 50 mm long and about 20 mm wide at the base, bright yellow, and slightly wrinkled or has small, closely grouped, merging brown-orange dots on a yellow background. In this case the limb is decidedly darker than the bright yellow throat. The stigmas are vertical, twice incised above; therefore trilobate.

C. evae is cultivated like *C. cordata* but it tolerates hard water well.

CRYPTOCORYNE FERRUGINEA Engler
Syn: *C. fusca* de Wit, *C. tortilis* de Wit
Incorrect name: *C. longicauda*

This species comes from Sarawak and is very rarely cultivated (usually under the incorrect name *C. longicauda*).

The leaves are 15 to 25 cm long; the petiole is usually as long as the blade or shorter. The blades are cordate, lanceolate to ovately rounded. The base is lobate or nearly abruptly lobate and the tip

is usually sharp, elongated, rarely blunt. The upper surface of the blade is green while the lower surface is white-green or reddish, nearly smooth, irregularly alveolate to bullate. The blades are 10 to 15 cm long and about 50 mm wide. The reverse side is sparsely or densely haired; the prominent, reddish brown hairs are setiform and intermingled with silver-white, glossy crystals that are 2.5 to 5 mm long.

The inflorescence reaches a length of 7.5 to 12.5 cm. The kettle, symmetrically curved inside, has the lower half deep purple with light red points; the upper half is lighter, with purple spots. The tube is absent and the limb is constricted above the kettle; it opens through a lateral suture. Above (outside) it is light yellow to chocolate-brown or reddish, often vertically striped; inside the lower part (about 25 mm) is brown-red, finely spotted and the upper part is brown-red or yellow-brown, strikingly ciliated.

C. ferruginea is a rare species, only seldom imported. It grows better emersed with 100% humidity than when submersed. In aquariums it is best cultivated in diffused light and in crystal clear, aged water.

CRYPTOCORYNE GRACILIS de Wit

C. gracilis is native to Sarawak and without any doubt closely related to *C. elliptica*.

The leaves are 50 to 75 mm long, with petioles that are as long or a little longer than the blades that are ovate to elliptical, abrupt, or lobate at the base. The upper surface of the leaf is green or bronze-brown-green; the lower surface is usually purple, remotely and slightly alveolate or smooth. The blades are 25 to 50 mm long and 15 to 30 mm wide. The color of the leaves is very variable, ranging from dark bronze-green to yellowish brown and dark purple. The leaf blades are often lattice-like, trimmed with darker stripes.

The inflorescence is 50 to 75 mm long. The kettle and the tube are nearly colorless and translucent. The limb reaches up to 40 mm long; the broad base is prolonged into a caudicle, 15 to 30 mm long. At the base of the limb there is a dark red or violet spot covering two-thirds of the broadened base. The tip and the caudicle are light purple or nearly colorless. The throat inwards is violet or spotted with purple and the collar is inconspicuous, but a dark black-violet zone is present in its place.

C. gracilis is one of the rarest species in our aquariums. Its small size makes it useful for small aquariums. The cultivation of *C. gracilis* is similar to that of *C. cordata*.



Mr. T.J. Horeman photographing a collection of *Cryptocoryne evae* at a typical site in Thailand where cryptocorynes are found.

CRYPTOCORYNE GRIFFITHII Schott (Ill. 433)

The habitat of this species is the Malay Peninsula and it differs from *C. cordata* by its shorter growth and inflorescence. Without the flower plants can hardly be distinguished. In contrast to *C. cordata*, the inflorescence (7.5 to 12.5 cm long) of *C. griffithii* is usually shorter than the leaves. The peduncle, often reaching a length of 75 mm, is variable. The colorless or pink kettle appears sometimes very thin, otherwise swollen, and the upright tube is either only as long as the kettle or much longer. The ligulate triangular limb has a dilated base; it is almost without a caudicle, purple, very warty and rough, and 20 to 30 mm long. A distinct collar is present in the red throat.

The name *C. griffithii* is frequently cited in aquarist literature, but it seems that this species has not yet been imported into Europe.

CRYPTOCORYNE HEJNYI Rataj
Incorrect name: *C. purpurea* Ridley (Ill. 432)

With its dark-striped leaf blades and bright limb of the spathe this species, belonging to the most beautiful representatives of *Cryptocoryne*, is commonly cultivated in aquariums and probably

comes from Malaya. It is distinguishable from *C. cordata* by a vermilion red limb and a throat that is not funnel-shaped, and from *C. griffithii* by the absence of a collar.

The leaves are 10 to 15 cm long, with petioles varying in length. The elliptical or cordate blades (base is abrupt or indistinctly lobate) are usually twice as long as they are wide and with transverse purple, pink or red-brown stripes. They are often 67 mm long and 25 mm wide.

The inflorescence (10 to 20 cm long) has a white or pink kettle. The throat is not dilated (not funnel-shaped); it is smooth, yellow or light orange and much lighter than the limb. The limb is usually 40 cm long, bright vermilion red, finely veined, without a collar, and with a caudicle up to 20 mm long.

Cultivation is similar to that of *C. cordata*.

CRYPTOCORYNE JOHORENSIS Engler (Ill. 437)

C. johorensis is native to the Malay Peninsula (Johore), but according to the information of professional collectors *C. johorensis* is also to be found in Sarawak (Tekalong-Dor) and perhaps also in Sumatra (Djambi, Palembang). However, this information has not been verified.

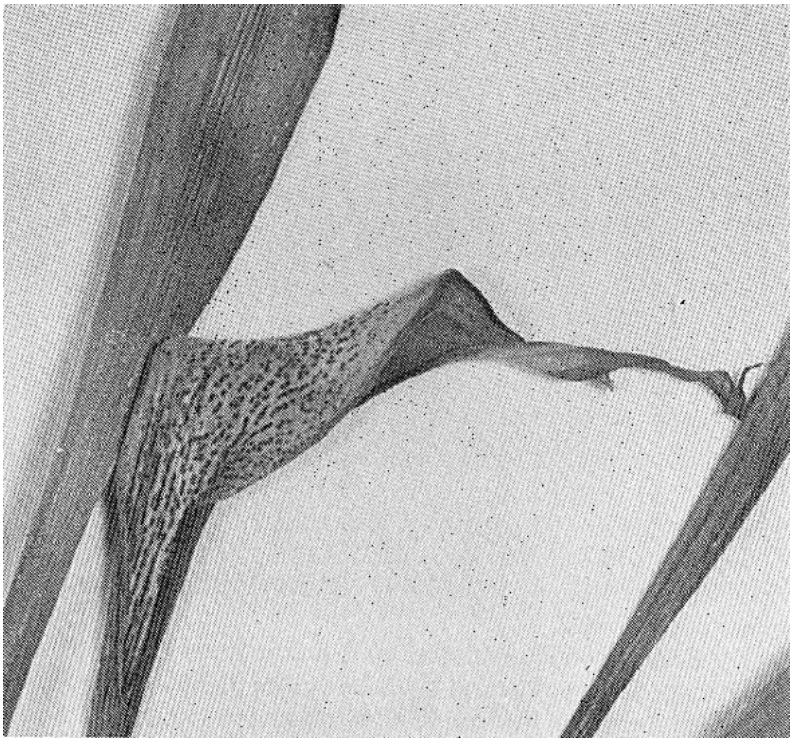
From an oblique rhizome up to four to seven leaves (10 to 20 cm long) develop. The leaf blades are green (lighter on the reverse side) and cordate; the base is lobed, elongated and pointed on the tip. Their margins are finely dentate and the surface of the blade is smooth or slightly bullate, usually 75 mm long and 50 mm wide. Emersed plants found in sunny situations have red-brown areas among the secondary nerves.

The inflorescence is longer than the leaves, reaching 17.5 to 25 cm; the length of the caudicle is usually 60% of the whole length. The limb is dish-shaped in the basal part, 15 mm wide and 30 mm long, wine-red and slightly wrinkled at the inside. A collar separates the limb from a colorless throat.

This species requires diffused light and a planting medium that is poor in nutrients. It is not exacting in its requirements but propagation is slow. This is why we rely mainly on imported specimens.

CRYPTOCORYNE KORTHAUSAE Rataj
Incorrect name: *C. albida* Parker (Ill. 249, 437)

The leaves are 10 to 15 cm long, with elliptical narrow leaf blades that are up to 10 cm long and 10 to 15 cm wide; the margins are usually undulate. In both emersed and submersed plants the leaves are always green without red lines.



Beautifully patterned and twisted limb of the inflorescence of *Cryptocoryne korthausae*.

The inflorescence is usually 10 cm long. The kettle is one third from the top of the inflorescence and turns inward and is very constricted; it is purple along the whole length on the inside, deeper purple in the upper part. The tube is twisted once to three times or nearly upright. The limb (25 to 40 mm long) is cream-white with pink or red dots, elongated at the tip and is usually horizontally twisted backwards into a spiral.

C. korthausae has been mistaken for *C. albida* and was cultivated under that name. Its origin is not known. *C. korthausae* prefers the emersed to the submersed conditions. It differs from *C. costata* by having: (1) the inner part of the kettle red, (2) a limb that is elongated and twisted horizontally backwards, and (3) green leaves that are without red lines.

CRYPTOCORYNE LEGROI — see *C. walkeri*

CRYPTOCORYNE LINGUA Beccari ex Engler
Syn: *C. spathulata* Beccari ex Engler (Ill. 436, 440, 441)

This species is a native of Borneo. It closely resembles *C. versteegii*, but differs from the latter mainly in its smaller size.

The leaves (usually 12.5 cm long) are arranged in a rosette; the petioles are broad, a little longer than the blades. These flat, fleshy, thick blades are spoon-shaped or spathulate and about 50 mm long and 25 mm wide. The base of the blade is decurrent, rarely lobate, pointed at the tip with hardly visible nerves.

The inflorescence is 50 to 75 mm long. The limb, widely open at the basal part, is light yellow in the throat with deep purple spots. The rest of the limb is extended into a long, upright dark purple caudicle. These two colored areas of the limb are not separated by a collar.

C. lingua requires higher temperatures (68° to 77° F or 20° to 25° C), acid water, and a fair amount of light. Like all bright green species it can withstand sunlight. It is propagated best in the emersed condition in paludariums and terrariums; propagation under water is very slow.

CRYPTOCORYNE LONGICAUDA — see *C. ferruginea*

CRYPTOCORYNE LUCENS de Wit (Ill. 441)

This cryptocoryne probably originates from Ceylon and was described from plants cultivated in artificial conditions.

The leaves, 15 to 30 cm long, have petioles that are red at the base and usually one and a half times longer than the blades. The exceptionally long blades are oblong, lanceolate (both sides decurrent), and are usually widest at the middle part, where the margins are nearly parallel. The blades are usually 75 mm long and 15 mm wide, bright green (lower leaf surface is lighter than the upper). The main rib is elevated and the tip of the blade does not bend downwards.

The inflorescence is about 75 mm long and often has a very long peduncle. The limb (13 mm long) is twice as long as it is wide. It is triangular, without a caudicle, sometimes twisted, reddish brown, dull and warty. The limb is separated by a collar from the throat which is of the same color as the limb or bright red.

C. lucens is cultivated like *C. nevillii*.

CRYPTOCORYNE LUTEA — see *C. walkeri*

CRYPTOCORYNE MINIMA Ridley (Ill. 444)

C. minima comes from the Malay Peninsula.

The leaves (5 to 10 cm long) have petioles that are as long as the blades or a little longer. The long, ovate blades have decurrent bases, are usually widest in the lower third, and have undulate margins. The blade is 25 to 37 mm long and about 25 mm wide; the upper leaf surface is green, while the lower surface is purple-red and occasionally alveolate (only in the submersed form).

The inflorescence is 50 mm long, but considering that the limb is bent downwards it is in fact only 25 mm tall. The terminal part of the tube is constricted. The limb is as long as the kettle and the tube taken together. The tip of the limb touches the ground. The warty and dull yellow limb is spotted brown and separated by a distinct collar from the glossy, brownish black throat.

The cultivation of *C. minima* is similar to that of *C. cordata*.

CRYPTOCORYNE NEVILLII Trimen (Ill. 445)

This plant is known only from Ceylon.

The leaves (5 to 10 cm long) have narrowly elliptical to lanceolate blades that are 37 to 75 mm long and 10 to 15 mm wide. The blade is narrow or abrupt at the base and the widest part is directly above the base and from there to the tip it is acuminate and sometimes recurved. The green lower leaf surface is somewhat lighter than the upper, with hardly visible nerves. There are stabilized forms with elliptical blades (about 10 mm wide, decurrent at the base) and forms with lanceolate blades (15 mm wide, cordate at the base).

The inflorescence is 50 to 75 mm long and the bright, warty, rough limb is about 20 mm long (3 to 3.5 times longer than the width). It has a short caudicle and a base with a distinct collar which separates the purple surface of the limb from the yellow throat of the tube.

C. nevillii can be easily cultivated in the aquarium and paludarium; it is not exacting with regard to the environment. Because the leaves are stiff, they are not susceptible to injury. It can withstand a bright light and is not affected by low temperatures. *C. nevillii* is especially suitable for foreground planting in the aquarium; propagation is by means of the long rhizomes.

CRYPTOCORYNE NURI Furtado (Ill. 444)

C. nuri originates from the Malayan Peninsula. The plants with dentate leaves offered in the trade under this name usually belong to *C. siamensis* var. *ewansii*. Both species are distinguishable only when in flower.

The leaves (10 to 15 cm long) have petioles that are as long as

the blades or slightly longer. The blades are usually elliptical, widest in the middle (both sides nearly symmetrically narrowed). The lower third to half of the blade (90 mm long and 25 mm wide) is distinctly dentate and the upper surface is glossy green (sometimes with transverse stripes) while the lower surface is rarely green, usually dark red-brown.

The inflorescence is 7.5 to 15 cm long and is shorter than the leaves or of the same length. The white kettle is slightly constricted at the center. The tube is white or pink. The ligulate limb (38 to 50 mm long) is sometimes extended into a caudicle. The base of the limb is distinctly dilated up to 25 mm, dark red or purple, warty and rough. The collar is distinct and the throat is light red.

This species is one of the most decorative plants, but its propagation is difficult and slow. Aquarium shops are entirely dependent on the imports from natural sources. *C. nuri* is cultivated like *C. cordata.*

CRYPTOCORYNE PARVA de Wit (Ill. 113)

A species (probably from Ceylon) that was described from plants commonly imported into Europe for aquariums. It is one of the most easily cultivated plants both in emersed and submersed forms. It easily propagates vegetatively and as new plants arise on a strong rhizome (often longer than the leaves), they grow in abundant groups with numerous plants.

The leaves are 50 to 55 mm long; the petioles are usually twice as long as the blades. These blades are narrowly elliptical (both sides nearly symmetrically narrowed), widest at the lower third or in the center and the tip is usually bent downwards. The grass green blade with hardly visible nerves is 25 mm long and 5 to 7.5 mm wide.

The inflorescence (25 mm long) has a white kettle and a white or pink tube narrowed a little at the throat. The triangular, ligulate limb is about 10 mm long, without a caudicle, twice as long as wide, warty and rough, and bright purple red; this coloring is separated from the whitish throat by a nearly black collar.

CRYPTOCORYNE PETCHII Alston (Ill. 56, 61)

Another plant from Ceylon and without doubt related to *C. becketii.* It differs from *C. becketii* by its smaller growth and by having an inflorescence with a distinctly darker green limb and a red throat in the tube. The limb is wartily dentate on the margins on the whole length (only in the base with *C. becketii*). *C. petchii* has forty-two chromosomes while *C. becketii* has only twenty-

eight. Sterile and submersed forms are scarcely distinguishable.

Emersed leaves (10 to 20 cm long) have petioles that are reddish brown and one and one-half to two times as long as the blades. The lanceolate blades are cordate at the base, or elliptical and narrowed at the base, rarely shallowly lobate, and widest in the center or in the lower third. The upper surface of the blade is olive-brown or brownish red, the lower surface red or pink. The blade is usually 75 mm long and 20 mm wide. Submersed blades are narrower with undulate margins.

The inflorescence is 7.5 to 10 cm long; the kettle as well as the tube is pink or light brown. The limb is ligulate, upright (37 mm long), olive-green, dull, silky smooth and finely wrinkled. The margins are warty and dentate along the whole length. The very dark purple-brown or chocolate-brown throat has a distinct dark brown collar.

This amphibious plant tolerates hard water and low temperatures and is also not affected adversely by either bright light or rather shady conditions. Propagation is like that of the preceding species.

CRYPTOCORYNE PONTEDERIIFOLIA Schott subspecies *SARAWACENSIS* Rataj (Ill. 56, 61)

C. pontederiifolia comes from Sumatra and is not cultivated. In recent years there are plants imported to Europe from Borneo described as *C. pontederiifolia* subsp. *sarawacensis* in 1975.

The leaves (10 to 15 cm long) have petioles that are as long as the blades. The blades are cordate and elliptical, sometimes indistinctly undulate (the base with dentate margins), membranous and both sides of the blade are green.

The light purple inflorescence is 7.5 to 10 cm long. The kettle is dilated upwards; in the lower half in the inside, finely wrinkled vertically; in the center constricted, and from there upwards, deep violet or spotted wine-red. The tube is as short as the kettle. The basal part of the limb is wine-red inside; without a collar, transversally wrinkled and warty; the throat is oblique so that the caudicle part of the limb is at the side of the extended axis of the tube.

C. pontederiifolia subsp. *sarawacensis* grows well both emersed and submersed. Emersed plants are more decorative and variegated, and also flower easily. It is one of the most hardy cryptocorynes, requiring little attention. It propagates easily from root runners, will stand diffused as well as direct light, and will be popular among aquarists.

CRYPTOCORYNE PURPUREA Ridley — see *C. hejnyi*.

CRYPTOCORYNE RETROSPIRALIS (Roxb.) Fischer

C. retrospiralis ranges from India to Thailand and Laos. The green leaves are 10 to 30 cm long, linearly narrow (2.5 to 10 mm wide). *C. retrospiralis* does not do well underwater; it thrives practically only in the emersed state and is therefore wrongly included in aquarium literature. Plants offered under this name in aquarium shops are usually *C. tonkinensis*.

CRYPTOCORYNE SCHULZEI de Wit (Ill. 260)

Only very few plants of *C. schulzei* have been cultivated in indoor aquariums. It is one of the new varieties and it originates from Malaysia (Johore).

The usually horizontal, rarely upright leaves (10 to 15 cm long) have green or brown-red petioles that are as long as the blades or up to one-third to a half longer. The elliptical blades are one and a half to twice as long as wide (either side almost equally narrowed). The base of the blade is slightly lobulate. The upper leaf surface is green or brownish red with irregular stripes while the lower leaf surface is red-brown to bright purple. The blade measures 50 to 75 mm in length, about 25 mm in width.

The inflorescence is shorter than the leaves, usually 75 mm long. The tube and the kettle are colorless, in the upper third olive-pink. The limb is 25 mm long (including a 10 to 15 mm caudicle); the throat is brown-purple, the collar and the limb are yellow, warty and rough.

C. schulzei is cultivated like *C. cordata*.

CRYPTOCORYNE SIAMENSIS Gagnepain

Thailand is the home country of this species. Three varieties, each differing in the shape of the blade, are known: var. *siamensis* has elliptical blades, var. *kerri* has cordate blades, and var. *ewansii* has blades that are distinctly dentate in the lower third (similar to *C. nuri*).

CRYPTOCORYNE SIAMENSIS Gagnepain var. *SIAMENSIS*

The leaves are 15 to 20 cm long; their petioles are longer than the blades or nearly as long both in the emersed and submersed forms. The elliptical blades are widest in the lower third, 7.5 to 10 cm long and 37 to 50 mm wide. (Ill. 257)

CRYPTOCORYNE SIAMENSIS var. *KERRI* (Gagnepain) Rataj
Syn: *C. kerri* Gagn., *C. blassii* de Wit (Ill. 40)

The leaves (10 to 25 cm long) have petioles that are two to

three times longer than the blades (in submersed plants), or as long as the blades (in emersed plants). The blades are cordate and measure 37 to 75 mm long and 25 to 50 mm wide.

CRYPTOCORYNE SIAMENSIS var. *EWANSII* Rataj (Ill. 57)

The leaves of this variety are 15 to 25 cm long and the petioles (in both emersed and submersed plants) are very variable in length measuring 7.5 to 10 cm in the emersed plants and up to 25 cm in the submersed ones. The limb (25 to 45 mm long and 10 mm wide) has a short or long caudicle; it is uniformly colored bright yellow inside; the funnel-shaped throat is light yellow or whitish.

C. siamensis is cultivated like *C. cordata* but it comes from Thailand and is usually found growing on limestone. It is easily cultivated and tolerates hard water very well.

CRYPTOCORYNE SPIRALIS (Retz.) Fischer (Ill. 272)
Syn: *C. unilocularis* (Retz.) Roxb., *C. huegellii* Schott, *C. tortuosa* Blatter ex McCann

C. spiralis inhabits India, Bangladesh, and probably Ceylon.

The leaves (10 to 20 to 75 cm long) have ribbon-like or oblong blades that are lanceolate and green. The inflorescence is 10 to 25 cm long and without a tube. The limb is usually 75 mm long, spirally twisted and longitudinally ligulate. It is purple-red, obliquely wrinkled and warty inside.

C. spiralis is mainly an emersed species and not a true aquarium plant.

CRYPTOCORYNE THWEITESII Schott (Ill. 257, 273)

Cultivated plants of *C. thweitesii* from Ceylon grow very well both in submersed and emersed forms. They are cultivated emersed on a neutral peat substratum; plants propagate quickly and the typical bronze colored leaves develop if regularly exposed to sunlight. The plants flower easily and often.

The leaves (10 to 15 cm long) are spread out almost horizontally and the petioles are shorter or as long as the blades which are entire; the margins (at least the lower third) are distinctly dentate. The blade is widely elliptical; the base is slightly decurrent or shallowly cordate and the tip is blunt. The main rib is much more prominent than the secondary nerves. Blades in the emersed form are bronze, brownish red and dull. They are finely granulated on the upper side and 50 to 75 mm long and 15 to 37 mm wide.

The inflorescence measures 7.5 to 10 cm in length. The kettle is colorless; the tube is only 15 mm long, in the lower part colorless, toward the top pink. The limb (25 to 75 mm long) is inside of the

widened basal part cream white to yellow, dark purple, densely spotted. It is elongated into an upright caudicle which is somewhat longer than other parts of the inflorescence.

Like *C. cordata*, this species is cultivated under water.

CRYPTOCORYNE TONKINENSIS Gagnepain (Ill. 256)

This plant from Vietnam is wrongly offered as *C. retrospiralis*.

The roots are banded, with numerous sprouting leaves (20 to 40 cm long); the blades are linear to strap-like with parallel margins. In emersed plants they are olive-green, 15 to 20 cm long and about 5 mm wide; in submersed plants they are reddish brown, 20 to 40 cm long and 5 to 15 mm wide. Their margins are always alveolate so that the margins appear distinctly and thickly undulate. The inflorescence of emersed plants is 10 to 15 cm long while in the submersed plants it is 20 to 25 cm long. The kettle is constricted in the upper third; the top is reddish, the base lighter. The brown-green tube is spirally twisted. The twisted limb is not dilated at the base; inside it is light olive-green or red.

These plants are adapted to the submersed way of life. In the emersed form they can only be cultivated as dwarf forms in 100% humidity. *C. tonkinensis* differs from *C. retrospiralis* by having bullate and undulate leaf blades both in submersed and emersed forms and by having a uniformly colored limb in the inflorescence. Growing in nature on limestone, *C. tonkinensis* tolerates hard water. It is cultivated like *C. balansae* and grows well in artificial light.

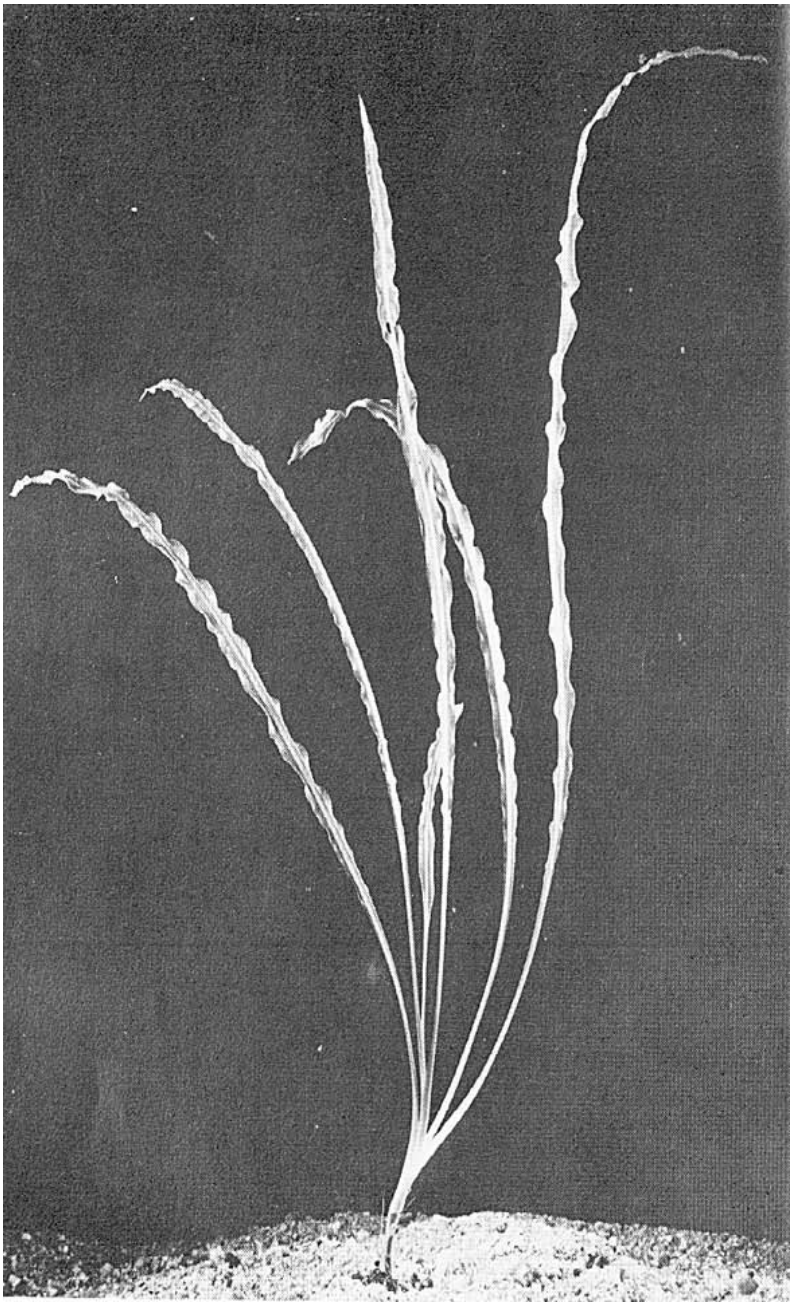
CRYPTOCORYNE USTERIANA Engler

Syn: *C. aponogetifolia* Merril

C. usteriana is endemic to the Philippines.

The leaves are 20 to 70 cm long and the length of the petioles is very variable. The leaf blades in emersed plants are oblong-lanceolate with abrupt, cordate or decurrent bases 15 to 25 cm long and 25 to 50 mm wide, and bullate (embossed). In emersed plants the leaf blade is 20 to 40 cm long and usually 37 mm wide, ribbon-like, green-brown, trimmed on both sides with two to three rows of prominent and deep blisters.

The inflorescence reaches a length of only 50 to 75 mm in emersed plants but in submersed plants the length of the tube is adapted to the height of the water and the complete inflorescence reaches up to 25 cm. The upright, ligulate limb is usually 37 mm long and uniformly colored dirty flesh-red.

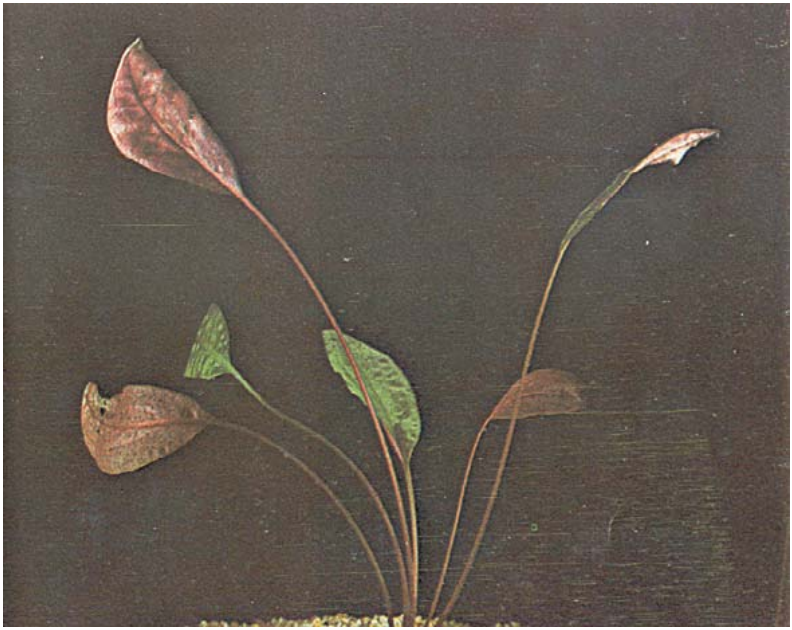


Cryptocoryne tonkinensis.



Opened inflorescence of *Cryptocoryne thweitesii* showing the purple spots inside the limb.

Cryptocoryne siamensis var. *siamensis*.



C. usteriana is cultivated in moderately acid water in artificial as well as natural light; the amount of light is not critical. It does not withstand being transplanted and needs a long time before it can resume its growth. Propagation by rhizome runners is slow. On account of its robust growth, it serves as a contrast to shorter *Cryptocoryne* species with colored leaves. *C. usteriana* is rare but it grows well in submersed conditions.

CRYPTOCORYNE VERSTEEGII Engler in Lorentz (Ill. 259)

This cryptocoryne is found only in New Guinea. The leaves (10 to 15 cm long) have thick, green petioles that are as long as the blades or twice as long. The blades are fleshy thick, green, cordate or nearly spathulate-triangular and with abrupt or cordately lobate bases. The lower third of the blade is widest and from there narrows into a rather blunt tip. They are usually 50 mm long and 25 to 37 mm wide.

The inflorescence is 5 to 10 cm long. At the basal opened part of the limb the throat is uniformly colored yellow and the remainder of the limb is extended to a very short, purple-red caudicle.

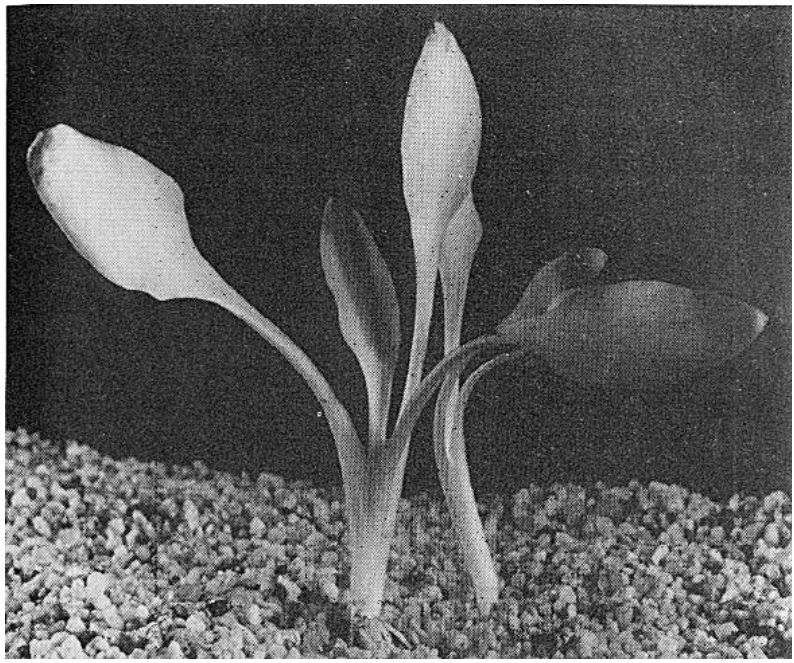
In nature it generally grows in emersed condition and is therefore suitable for terrariums; if cultivated under water it needs more light than other species. Even under favorable conditions the growth is slow and propagation is difficult; not more than one or two runners a year are formed. *C. versteegii* closely resembles *C. lingua.*

CRYPTOCORYNE WALKERI Schott (Ill. 260-1, 264, 269, 276)

This *Cryptocoryne* species is confined to Ceylon. Three varieties of *C. walkeri* are known. Emersed and submersed forms of var. *walkeri* and var. *lutea* have green leaves, while the emersed plants of var. *legroi* have red-brown leaf blades. The blades of var. *lutea* are shorter and narrower than those of var. *walkeri*. The submersed forms of all three varieties are hardly distinguishable from each other.

The leaves are 10 to 15 to 25 cm long. The petioles in emersed plants are two to three times longer while in submersed plants they are one and one-half to twice as long as the blade. The oblong, lanceolate, green or red-brown blades are three to four and one-half times longer than the width, usually 5 to 10 cm long and 12.5 to 37 mm wide.

The inflorescence (7.5 to 12.5 cm long) is upright or loosely twisted, with a light pink tube. The tip of the ligulate limb is sometimes arched downwards. Initially the limb is yellow, after two to



Cryptocoryne versteegii.

three days it becomes darker yellow-green; the throat is light, often with pink points. The collar is sometimes hardly visible, but at least indicated. *C. walkeri* can be grown in both submersed and emersed conditions and it is one of the more resistant *Cryptocoryne* species. Cultivation is similar to that used for *C. becketii*; propagation is by way of rhizome runners.

CRYPTOCORYNE WENDTII de Wit (III. 74)

C. wendtii comes from Ceylon and having five varieties it is the most variable species among the cryptocorynes.

The leaves are described in the discussion of the individual varieties.

The inflorescence (25 to 75 mm long) has a limb that is twisted directly above the throat, so that the throat sometimes has a narrow fissure (hardly visible); otherwise the throat is partly opened but it is always oblique. The limb is purple-brown, finely wrinkled, and the margins are dentate. The collar is distinct, dark purple to black and the throat is dark violet with fine white points.



Cryptocoryne schulzei with inflorescence. Photo by T.J. Horeman.

Cryptocoryne walkeri var. *lutea*.





Inflorescence of *Cryptocoryne walkeri* var. *lutea*.

CRYPTOCORYNE WENDTII var. *WENDTII* (Ill. 265)

The leaves are 15 to 20 cm long; the petioles are green or reddish, approximately as long as the blades. The elliptical blades are 7.5 to 10 cm long and 25 to 37 mm wide, with truncate or cordate bases. The upper surface in emersed forms is distinctly bullose, green while the lower surface is lighter. In submersed forms the "blisters" are sometimes visible and the blades are green or olive-green with transverse stripes.

The inflorescence is usually 50 mm long.

CRYPTOCORYNE WENDTII var. *JAHNELII* Rataj
Incorrect name: C. *wendtii rubra* (Ill. 265)

The leaves of var. *jahnelii* are 15 to 20 cm long and the brownish red petioles are as long as the blades. The elliptical blades are 5 to 10 cm long and 25 mm wide, red-brown, and irregularly bullose (blistered). The "blisters" in submersed plants are not always indicated. The margins are always distinctly undulate.

The inflorescence is 50 to 75 mm long, usually darker as in *C. wendtii* var. *wendtii*.

CRYPTOCORYNE WENDTII var. *KRAUTERI* Rataj (Ill. 263)

The leaves are 15 to 20 cm long. The elliptical blades (7.5 to 12.5 cm long and 25 to 37 mm wide) are widest at the center, smooth, and with slightly undulate margins. The lower third of the blade is distinctly dentate. The upper surface is bronze-green or bronze-brown, dull and granulate, while the lower leaf surface is lighter green or pink.

The inflorescence is 7.5 to 10 cm long.

CRYPTOCORYNE WENDTII var. *NANA* Rataj

The leaves of var. *nana* are 7.5 to 12.5 cm long and the blades are 25 to 50 mm long and 15 to 17 mm wide. The shape of the blade is variable, from lanceolate to elliptical. The upper surface is green while the lower leaf surface is olive-green to olive-brown.

Its inflorescence is only 50 mm long.

CRYPTOCORYNE WENDTII var. *RUBELLA* Rataj

The leaves are 10 to 15 cm long with brown petioles. The blades in the submersed form are 75 mm long and 10 mm wide, green-brown or red-brown with undulate margins, usually with transverse dark stripes.

The inflorescence is 50 mm long.

All of the varieties of *C. wendtii* are easily cultivated. They reproduce as quickly as *C. becketii* and being more decorative

than other species cultivated up to now they should be regarded as popular cryptocorynes for aquariums and terrariums. These varieties can withstand subdued as well as direct light. They tolerate temperatures down to 59° F (15° C) but grow best at temperatures between 68° to 77° F (20° to 25° C).

CRYPTOCORYNE WILLISII — see *C. axelrodii*

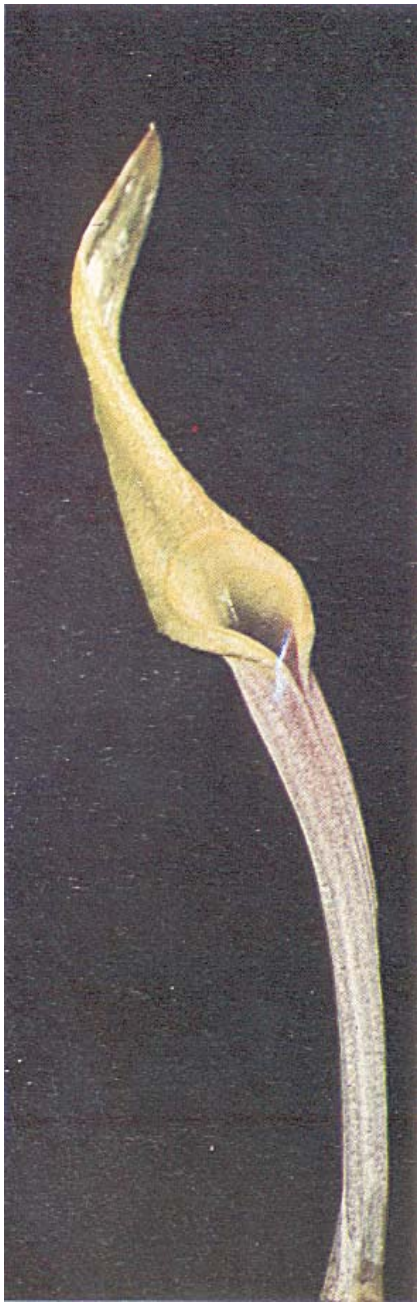
CRYPTOCORYNE ZEWALDAE de Wit

This plant is probably from Malaya and whether this species has ever been cultivated is not certain.

The leaves are 15 to 25 cm long. The cordate blades have undulate margins and are slightly alveolate. The blades measure 50 to 75 mm long and 37 to 45 mm wide. The upper surface is green or olive-brown while the lower surface is purple-red and glossy.

Cryptocoryne wendtii var. *krauteri*, emersed form.

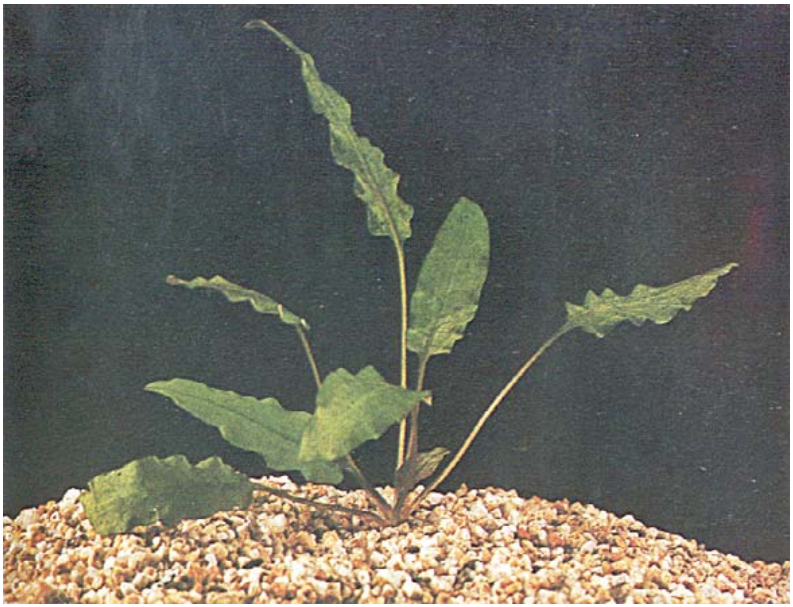




Inflorescence of *Cryptocoryne walkeri* var. *legroi*.



Cryptocoryne walkeri var. *legroi*.



Cryptocoryne wendtii var. *wendtii*.

Cryptocoryne wendtii var. *jahnelii*.



The inflorescence is 75 mm long but its limb being bent downward, it reaches to only about 35 mm high; the tip of the limb touches the ground. The limb is glossy, dark purple, distinctly warty, and dilated at the base.

CRYPTOCORYNE ZONATA de Wit

C. zonata is found only in Borneo (Sarawak, Brunei).

The leaves (10 to 20 cm long) have cordate blades that are distinctly bullose or irregularly alveolate over the surface. The upper surface is deep green while the lower surface is purple. The leaf blade is 50 to 75 mm long and 25 to 50 mm wide. They aré sometimes cordate, membranous, and quite smooth in submersed plants.

The inflorescence is 10 to 15 cm long. The kettle is red at the base and at the tip, much lighter at the center. The limb (25 to 37 mm long) is widely opened; in the throat it is light bright yellow, on the surface deep bright yellow, and on the margins often darker (orange). The upper two-thirds of the limb and the caudicle are slightly warty (yellow red-bordered warts). The caudicle is sometimes darker, orange to red.

Cultivation is like that of *C. cordata.*

CRYPTOCORYNE ZUKALII Rataj (Ill. 267, 268)

C. zukalii is a species probably originating from Malaya.

The leaves (15 to 30 cm long) have blades that are cordate to round, slightly dentate, slightly bullose, and with short acuminate or blunt tips. The upper surface is dark green while the lower surface is usually red-violet. The blade measures 7 to 10 cm in length and 50 mm in width.

The inflorescence is 10 to 15 cm long. The upright tube is colorless and has thick purple dots and stripes. The throat is as narrow as the tube and not funnel-shaped. The ligulate limb is 35 to 50 mm long including a 10 to 20 mm long caudicle. The whole limb is uniformly colored brown-orange, smooth, and without a collar. The throat is of the same color as the limb except a little brighter.

C. zukalii is cultivated like *C. cordata.*

Cryptocoryne zukalii,
cultivated emersed.





Inflorescence of *Cryptocoryne zukalii*.

Cryptocoryne zukalii, cultivated submersed.





Opened kettle of *Cryptocoryne walkeri* showing the female flowers at the base and the male flowers at the top. Photo by T.J. Horeman.

KEY TO THE IDENTIFICATION OF THE SPECIES OF THE GENUS CRYPTOCORYNE

Not enough distinctive characters are present in the leaves of *Cryptocoryne* species to enable us to identify safely all the cultivated species. Both leaves and inflorescences are absolutely necessary for their determination. The following key is arranged according to these structures. The numbers enclosed in parentheses refer to the alternate choice or the second half of the couplet.

Key to Cryptocoryne Species

1 (4) Tube absent, inflorescence opening through a vertical suture 2

2 (3) Leaf blades oblong, lanceolate or ribbon-like . . *C. spiralis*

3 Leaf blades cordate or ovate . . . . . *C. ferruginea*

4 Tube present, opening through a horizontal throat. . . . 5

5 (6) Limb of inflorescence on the margins fringed . . . *C. ciliata*

6 Limb not fringed 7

7 (20) Leaf blades oblong, lanceolate, 8 to 20 times or even more times longer than wide 8

8 (17) Limb in the basal part at most half as wide as the tube 9

9 (12) Leaf blades entire or undulate only on the margins; if bullose, then always narrower than 1 cm 10

10 (11) Limb trimmed with red dots and lines . . . . *C. retrospiralis*

11 Limb uniformly colored red or yellow-green . . . . . *C. tonkinensis*

12 Leaf blades bullose 13

13 (16) On the blade only, one row of blisters on both sides 14

14 (15) Blades ribbon-like, margins alveolate and densely undulate . . . . . *C. tonkinensis*

15 Blades oblong, lanceolate, in the center alveolate, margins nearly entire . . . . . *C. balansae*

16 On the leaf blade both sides 2 to 3 rows of blisters . . . . . *C. usteriana*

17 Limb distinctly dilated, 3 times wider than the tube . . . 18

18 (19) Emersed leaves red, limb with distinct caudicle . . . . . C. *costata*

19 Emersed leaves green, limb without caudicle, horizontally twisted . . . . . *C. korthausae*

20 Blades widely elliptical to cordate, maximum 2 to 4 times longer than wide, limb not spirally twisted 21

21 (26) Limb extended into a caudicle longer, or as long, as all the other parts of the inflorescence together 22

22 (23) Limb white or yellow . . . . . *C. thweitesii*

23 Limb red 24

24 (25) Throat with collar, tube longer than kettle . . *C. johorensis*

25 Throat without collar, tube shorter than kettle . . . . . *C. pontederifolia*

26 Limb without caudicle or the caudicle reaches maximum the half of the inflorescence length 27

27 (30) Blades leather-like, thick, green on both sides, 1.5 to twice as long as wide 28

28 (29) Limb at the base yellow, red spotted, with long caudicle . . . . . *C. lingua*

29 Limb at the base uniformly colored, with a very short caudicle . . . . . *C. versteegii*

30 Blades membranous, lower leaf surface often brown or red, if on both sides green, then lanceolate, 3 times or more longer than wide 31

31 (32) Tube distinctly shorter than the kettle . . . . . *C. auriculata*

32 Tube at least as long as the kettle 33

33 (38) Blades maximum 8 to 14 mm wide 34

34 (35) Limb short caudicle, throat yellow . . . . . *C. nevillii*

35 Limb triangular, throat not yellow 36

36 (37) Throat above nearly black, below colorless, limb bright purple . . . . . *C. parva*

37 Throat purple, limb pale, olive-red, dull . . . . . *C. lucens*

38 Blades wider than 16 mm 39

39 (48) Blades lanceolate, 3.5 to 5 times longer than wide, limbs never bright red 40

40 (43) Limb immediately after opening, twisted above the throat, so that the tube opens only through a larger or smaller fissure 41

41 (42) Throat forms an elliptical fissure, inside green-yellow or olive-yellow . . . . . *C. axelrodii*

42 Throat forms a very narrow fissure, inside red-brown . . . . . *C. wendtii*

43 Limb ligulate, the throat fully open 44



Inflorescence of *Cryptocoryne spiralis* with the characteristic spirally twisted limb.



Cryptocoryne thweitesii, emersed plant.

44 (45) Limb light yellow ..... *C. walkeri*
45 Limb not yellow 46
46 (47) Limb yellow-brown, the base dentate ..... *C. becketii*
47 Limb inside green, along the whole length dentate ..... *C. petchii*
48 Blades cordate or broadly elliptical, 1.5 to 2 to 2.5 times longer than wide 49
49 (50) Throat in the terminal part of the tube red or violet spotted ..... *C. gracilis*
50 Throat without spots 51
51 (52) Blades covered with crystalline cells ..... *C. affinis*
52 Blades without crystalline cells 53
53 (64) Throat with collar 54
54 (57) Limb as long as the kettle and tube together, bent downwards 55
55 (56) Limb purple-red, petioles 2 to 3 times longer than blades, leaves 15 to 25 cm long ..... *C. zewaldae*
56 Limb yellow, brown spotted, plants only 5 to 10 cm high ..... *C. minima*
57 Limb shorter than tube and kettle together 58
58 (61) Blades cordate, not blistered 59
59 (60) Limb and throat purple ..... *C. griffithii*
60 Limb yellow, throat red ..... *C. schulzei*
61 Leaf blades elliptical 62
62 (63) Blades smooth, only on the margins dentate ..... *C. nuri*
63 Blades blistered ..... *C. bullosa*
64 Throat without collar 65
65 (74) Throat funnel-shaped 66
66 (73) Limb or only the throat yellow 67
67 (68) Limb large, more than 5 cm long ..... *C. evae*
68 Limb 2.5 to 4 cm long 69
69 (70) Limb uniformly colored yellow ..... *C. siamensis*
70 Limb not uniformly colored 71
71 (72) Limb yellow, at the tip with small red warty dots ..... *C. zonata*
72 The surface of limb yellow, scattered with brown or pink areas ..... *C. didericii*

73 Limb and throat not bright yellow, usually purple, rarely dull brown-yellow ..... *C. cordata*

74 Throat not funnel-shaped 75

75 (76) Blades smooth, limb vermilion red ..... *C. hejnyi*

76 Blades blistered, limb orange-brown ..... *C. zukalii*

JASARUM STEYERMARKII Bunting

This plant is undoubtedly the newest import at present. It was found and described a few years ago in Venezuela. The elliptical leaf blades of *J. steyermarkii* are bullose (embossed); the petioles are rather short. Living plants were imported for the first time to Europe by Mr. J. Bogner from Munich. Without doubt this import represents a unique material cultivated under artificial conditions.

LAGENANDRA

Plants of this genus are found in Ceylon (four species) and in the southern part of India (three species). They are perennial plants with a robust rhizome. In the emersed form a firm, woody stalk is developed. The leaves with long petioles have ovate or lanceolate blades. The flowers are similar to those of the cryptocorynes but the pistils are arranged in spirals (not in a circle). *Lagenandra toxicaria* is one of the most poisonous plants known.

LAGENANDRA DALZELLII (Schott) Rataj

Syn: *L. meeboldii* (Engler) Fischer

L. dalzellii originates from India and Ceylon and it resembles some of the cryptocorynes. The plant is only 5 to 10 cm tall. The leaves with typically heart-shaped blades are green or bronze reddish brown as in *Cryptocoryne thweitesii*. *L. dalzellii* was first imported in 1974. It seems to require the same conditions of cultivation as *Lagenandra thwaitesii*.

LAGENANDRA KOENIGII (Schott) Thwaites (Ill. 277)

L. koenigii is from the same area as the preceding species. The leaves are 10 to 15 cm long. The deep green blades (10 to 20 mm long) are usually longer than the petioles and narrowly lanceolate. Unlike *L. thwaitesii* their leaf margins are not silvery. This species is among the newly imported novelties. It is suitable for smaller and medium size tanks.

LAGENANDRA LANCIFOLIA (Schott) Thwaites (Ill. 277)

This plant grows in Ceylon in periodically flooded marshes within the jungle and on the shady banks of moving as well as still waters. It will tolerate permanent cultivation under water. *L. lan-*



Cryptocoryne walkeri from Ceylon (Sri Lanka) with inflorescence. Photo by T.J. Horeman.



Lagenandra koenigii.

Lagenandra lancifolia.



cifolia is substantially smaller than *L. ovata* and it reaches a height of 25 to 30 cm.

The petiolate leaves have blades that are as long or shorter than the petiole, oblong-lanceolate, generally 75 mm long and 30 mm wide. The upper leaf surface is glossy grass-green; the lower surface is light green with white spots, especially along the center, about the midrib.

L. lancifolia is cultivated under conditions similar to those of *Cryptocoryne* spp., i.e., in moderately acid water with a richer planting medium. It requires plenty of diffused light and temperatures above 72° F (22° C). At lower temperatures the plant develops very sluggishly and eventually stops growing. Reproduction is slow; rhizome runners usually develop only after two to three years. Plants are most easily propagated from rhizomes cut off from the parent plant and cultivated in emersed conditions.

LAGENANDRA OVATA (L.) Thwaites (Ill. 279)

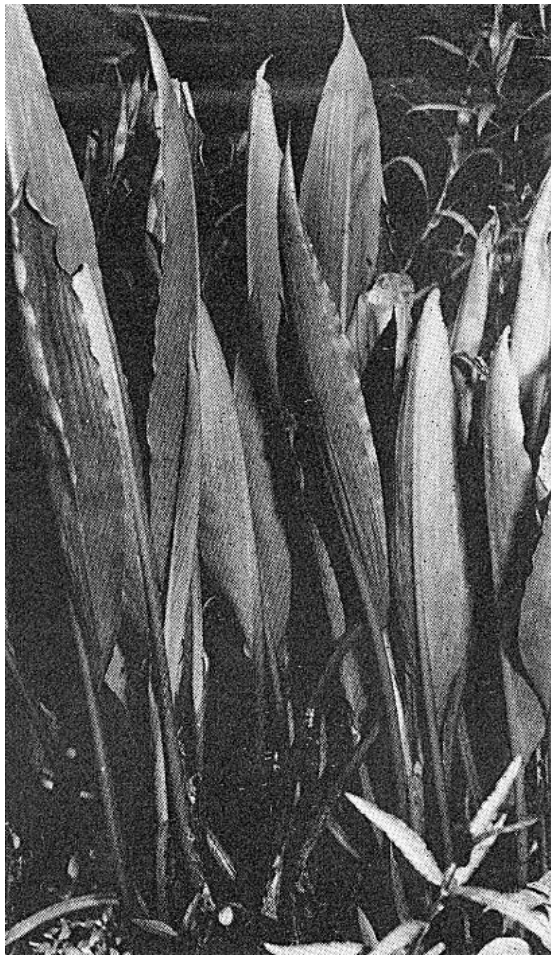
This inhabits the same place as the preceding species but allegedly it is also found in India. *L. ovata* is less suitable for aquariums because the leaves reach a length of up to 90 cm and under good conditions these can easily grow out of the water. The rhizome is robust, reaching up to 50 mm in diameter. The petiolate leaves are oblong-oval, acuminate. The blades in the submersed state are usually 20 cm long and about 75 mm wide, in the emersed form growing to 40 cm long and 12 cm wide. The upper leaf surface is glossy green while the lower surface is lighter in color.

L. ovata is cultivated like *Cryptocoryne ciliata*, i.e., in a poor medium and a moderately bright situation to prevent the leaves from growing out of the water. Propagation is more or less the same as the preceding species.

LAGENANDRA THWAITESII Engler

L. thwaitesii is native to Ceylon and is the most beautiful and at the same time the smallest member of this genus. In the wild it may reach a height of 25 cm but in the aquarium and the greenhouse emersed cultivated specimens do not grow more than 15 to 18 cm. The petiolate leaves are grass-green or grayish green. The whole blade is covered with silver-gray flecks. It is elongated lanceolate and about 10 cm long and 30 mm wide.

The plants are best cultivated in a temperature of about 72° F (22° C), in soft and moderately acid water, and a medium rich substrate. This species can stand more light than *L. ovata*. It is suitable for terrariums as well as aquariums.



Lagenandra ovata growing emersed.

ORONTIUM AQUATICUM L.

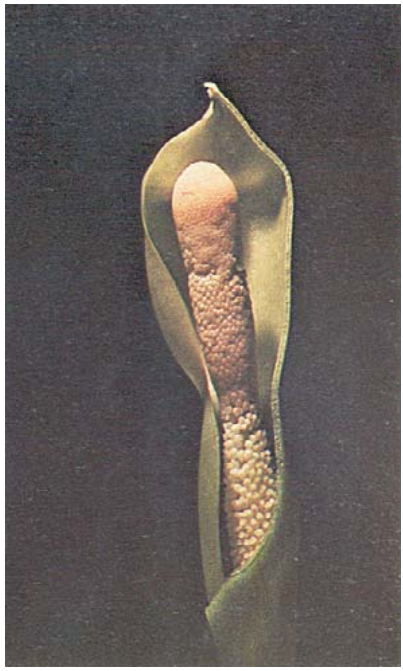
O. aquaticum occurs in shallow water in eastern North America and is frequently cultivated as a decorative plant in garden ponds. The often floating leaves are 15 cm long, with oblong blades. It is not suited for indoor tanks.

PELTRANDRA

There are three species of *Peltrandra* from eastern North America. They are found in shallow water and swamps. *Peltrandra virginica* is cultivated in garden ponds. Petioled leaves, up to 40 cm high, have sagittate blades that are 25 cm long. This plant is not suitable for aquariums.



Schismatoglottis.



Inflorescence of *Schismatoglottis* with the male and female structures exposed.

Pistia stratiotes together with *Salvinia* (smaller floating plants). Photo by Dr. Herbert R. Axelrod.



PISTIA STRATIOTES L. (Ill. 281)

This plant, often called water lettuce, is distributed throughout the tropical regions and occasionally penetrating into the subtropical zones. The main area of distribution extends from Paraguay and Argentina across Central America and the West Indian archipelago to the southern part of the U.S.A. (Texas and Florida). In Africa it is found throughout the whole equatorial region, including Madagascar. In Asia this plant is found everywhere between eastern India and the Philippines. It has become a serious pest in many regions.

The leaves, on a shortened axis, form a rosette and are of most varied shapes—round, or cuneate, lingulate, reversely cordate, etc. The rosette is 10 to 20 cm in diameter. The upper leaf surface is light green, sparsely haired; the lower surface is greenish. Flowers in short, laterally vented spathes develop from the axil of the leaf.

Having a dense root mass, up to 20 cm long, this plant is very useful as a spawning medium for various species of fish. Unfortunately it grows only on a very well lighted surface where it produces tender root runners at the ends of which the young plants develop. For cultivating this plant, temperatures around 64° to 72° F (18° to 22° C) are required, and it can be cultivated successfully even in garden ponds during the summer. However during the autumn it is very sensitive to the shortening of the daylight hours; it can hibernate in aquariums, but only if given plenty of additional artificial light. The plant should have light for approximately twelve hours each day.

Water lettuce can be kept only with difficulty if additional light is not provided; if this is not possible, the plants should be transferred to small, flat dishes filled with sand and covered by about 25 mm of water. This is done as early as September. As soon as they have taken root the water can be left to evaporate and the plants are watered only moderately afterwards. They can then lie dormant safely.

Since *Pistia* produces seeds easily, it can be sown in dishes of water every spring. As soon as the seedlings are about 10 mm long they are transferred to the water surface in the aquarium where they propagate vegetatively very fast.

SCHISMATOGLOTTIS (Ill. 280, 281)

Plants representing the genus *Schismatoglottis* have been imported from the Malay Peninsula but the species is not yet deter-

mined. The leaves are 30 to 60 cm long (in the aquarium only 20 to 25 cm long). The blades are elongately cordate, acuminate at the tip, green, and trimmed with a broad, irregular silver stripe along the middle rib. Emersed plants flower easily. The spathe is green and the flowers on the spadix are divided into the lower female and upper male parts.

Cultivation is similar to that of *Aglaonema.*

SPATHIPHYLLUM Schott (III, 421, 429)

Spathiphyllum is found mainly in South and Central America, and less frequently in Southeast Asia. The genus is represented by thirty-six species. Many are popular as ornamental indoor or greenhouse plants. Although a number of them grow in moist places, only one species has been tested successfully for permanently submersed growth.

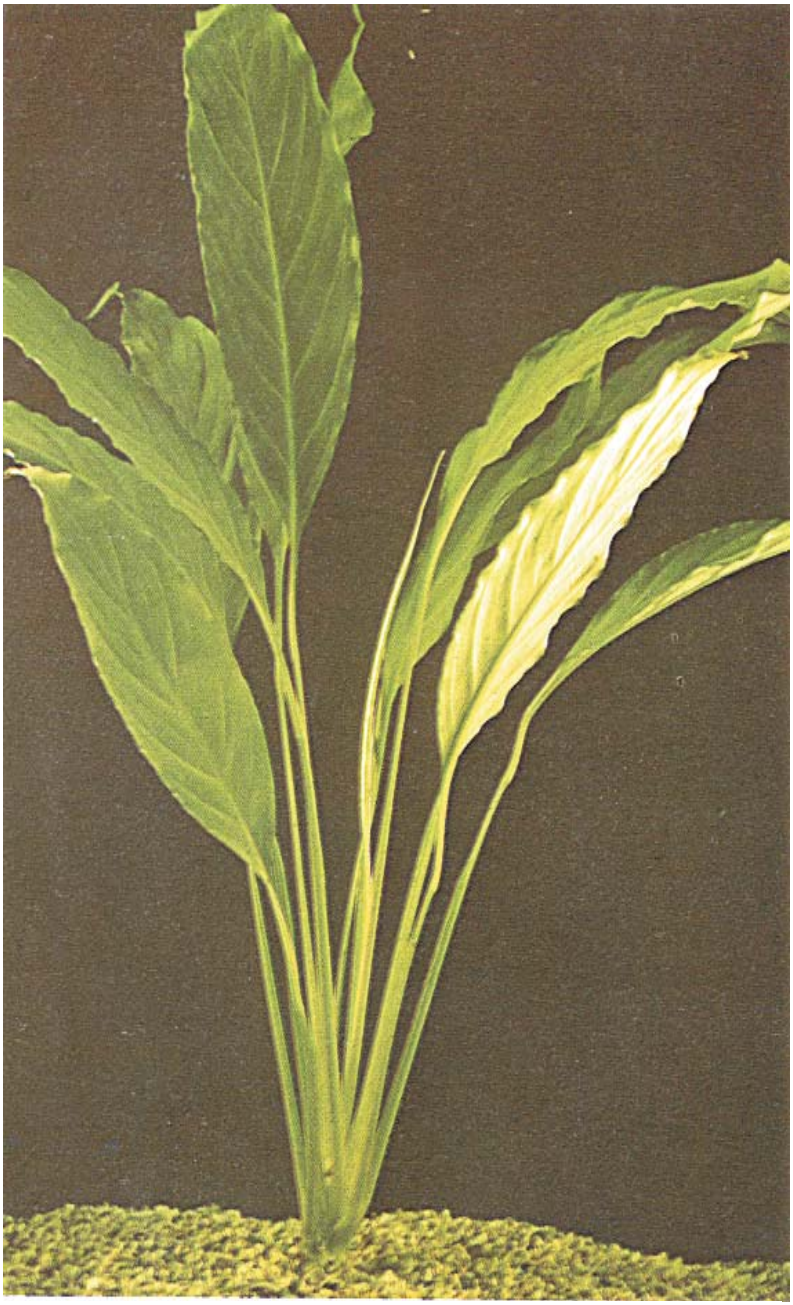
SPATHIPHYLLUM WALLISI Regel (Ill. 284)

This *Spathiphyllum* from Colombia is a perennial marsh plant. It is 50 cm tall but when cultivated under water it grows generally only to a height of 30 cm. The rhizome, from which petiolate leaves with a long lanceolate blade arise, measures up to 40 mm thick. The petiole is usually longer than the blade. The bright green blade is 30 to 60 mm wide and has margins that are moderately undulate. The blade is ornamented by fairly well elevated veins.

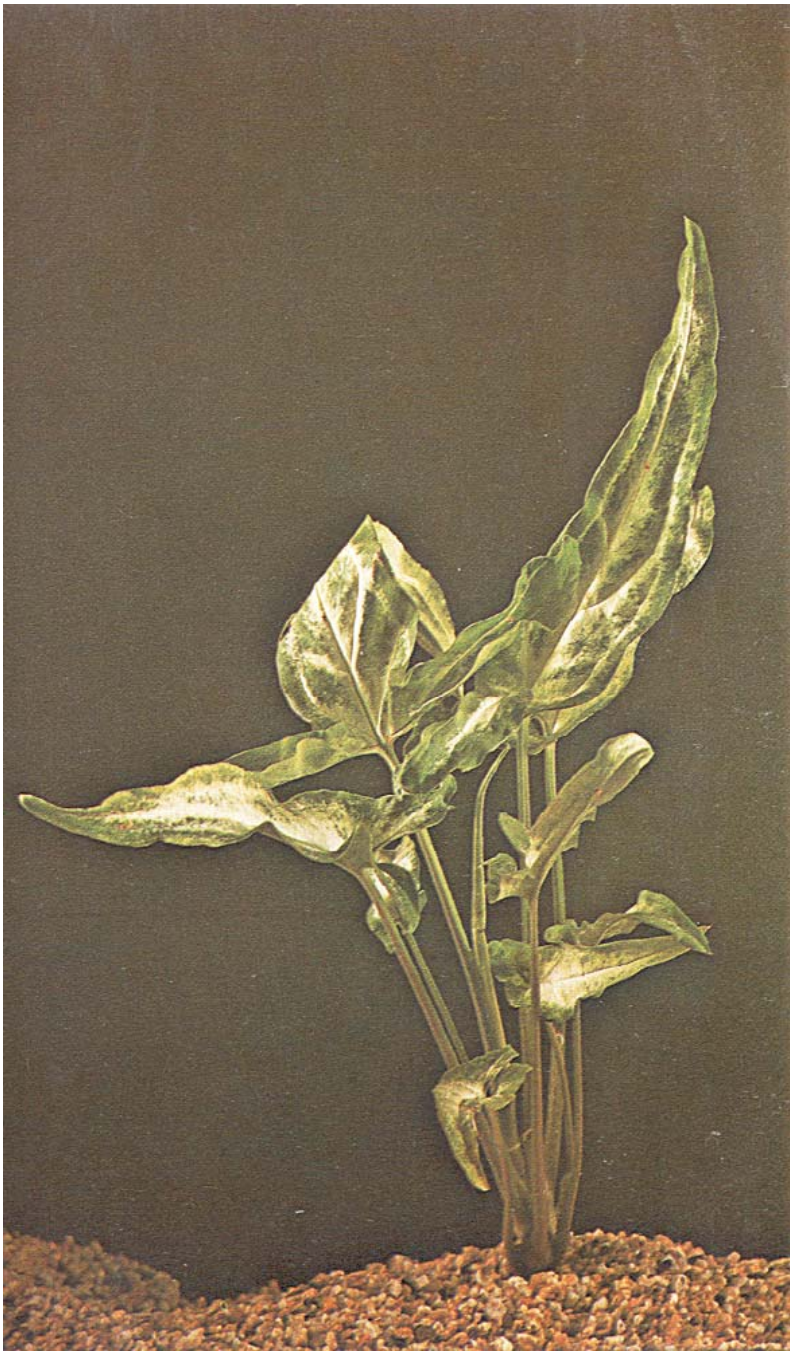
The cultivation of S. *wallisi* is similar to that of *Cryptocoryne* species, but unlike them it is not sensitive to excess light and it tolerates lower temperatures. In the water it remains in good condition all the summer but grows extremely slowly and often forms but a single leaf during the whole year. There are no known cases in which the plant developed runners under water; only emersed cultivated plants are propagated. They do well in flowerpots, provided they are treated in the same way as other plants commonly cultivated in greenhouses. Ten to fifteen young plants can be obtained by cuttings from the rhizome.

SYNGONIUM ALBOLINEATUM (Ill. 285)

This liana resembles the growth of plants belonging to the genus *Philodendron*. It is commonly cultivated as an indoor plant reaching a height of several feet. Petiolate leaves grow on its climbing stem at intervals of 5 to 15 cm. Their sagittate blades are about 7.5 to 10 cm long, green and trimmed with a silvery white or yellow line along the main nerves. If we wish to use this species for our tanks, we should cut the stem into pieces with a single leaf on



Spatiphyllum wallisii. **Opposite:** *Syngonium albolineatum.*



each of them. These cuttings are then planted in fertilized peat and watered well. They will take root within a short time and form rosettes of five to ten leaves, 10 to 15 cm long. They are then transplanted in this form into the aquarium. Their multi-colored and interesting leaves are very beautiful. They prefer diffused light, crystal clear acid water and are not sensitive to temperature changes.

TYPHONIUM FLEGELLIFORME (Lodd.) Blume (Ill. 288, 424)

T. flegelliforme is now imported regularly from Malaya. The leaves (up to 20 to 25 cm long) develop from little round tubers. The petioles are longer than the sagittate blades, which are deep green, 5 to 10 cm long, and have pointed lobules at the base.

Typhonium grows well emersed as well as submersed. In emersed cultures it propagates very quickly by producing new little tubers and flowers easily. The shape of the inflorescence is most attractive. An extended whip-shaped sterile part of the spadix grows from the kettle.

Very little is known about the cultivation of these plants in aquariums except that they propagate in an emersed form. They are planted under water with as few as four well developed leaves. Plants do not tolerate new water and they should be transplanted into mature, biologically balanced tanks with clean sand enriched with detritus and in places with indirect illumination.

ASTERACEAE (COMPOSITAE)

This very large family (900 genera) includes many well known decorative plants, such as the daisy, chrysanthemum, sunflower, etc. Many species grow in marshes but only ten genera include submersed plants. Most of them have not been imported yet and tested for aquatic purposes.

GYMNOCORONIS SPILANTHOIDES DC

G. spilanthoides is from tropical South America, where it occurs mainly in still or flowing waters and in marshes. The stems (about 10 to 15 mm thick) are erect at first, later becoming prostrate, rooting richly in many places. The elliptical to lanceolate leaves (5 to 12.5 cm long and 15 to 20 mm wide) are deep green and have inconspicuous undulated margins. The inflorescence is white (15 to 20 mm); the flowers are arranged on heads.

This plant can be propagated from any part of the stem having a pair of leaves. Emersed plants transplanted under water grow quickly and extend above the water surface. They do best

when planted in tanks with a shaded surface illuminated only from the sides. Plants acclimatized to submersed life can be used in any aquarium. They are extremely hardy and do well in clean neutral water. The plants are 30 to 40 cm long and in order to get widely branching bushes they are pinched at the tips.

BRASSICACEAE Burnett (Cress Family)

This family (formerly Cruciferae), with 375 genera and 3200 species, is very abundant and is widely distributed all over the world. A great number of representatives grow amphibiously. However only a few species can be used in the aquarium. *Cardamine lyrata* and the beautiful *Rorippa aquatica*, rarely *Subularia*, are cultivated.

CARDAMINE LYRATA Bunge (BITTER CRESS) (Ill. 424)

C. lyrata is distributed in East Asia and Japan. In the land form the plant has a prostrate or twisting stem but under water the feeble stems float vertically, up towards the water surface. The leaves are alternate, lyre-shaped, pinnate, round with short petioles, light green. The whole plant is very fragile. The inflorescence is a cluster; flowers are white, 5 to 10 mm in diameter.

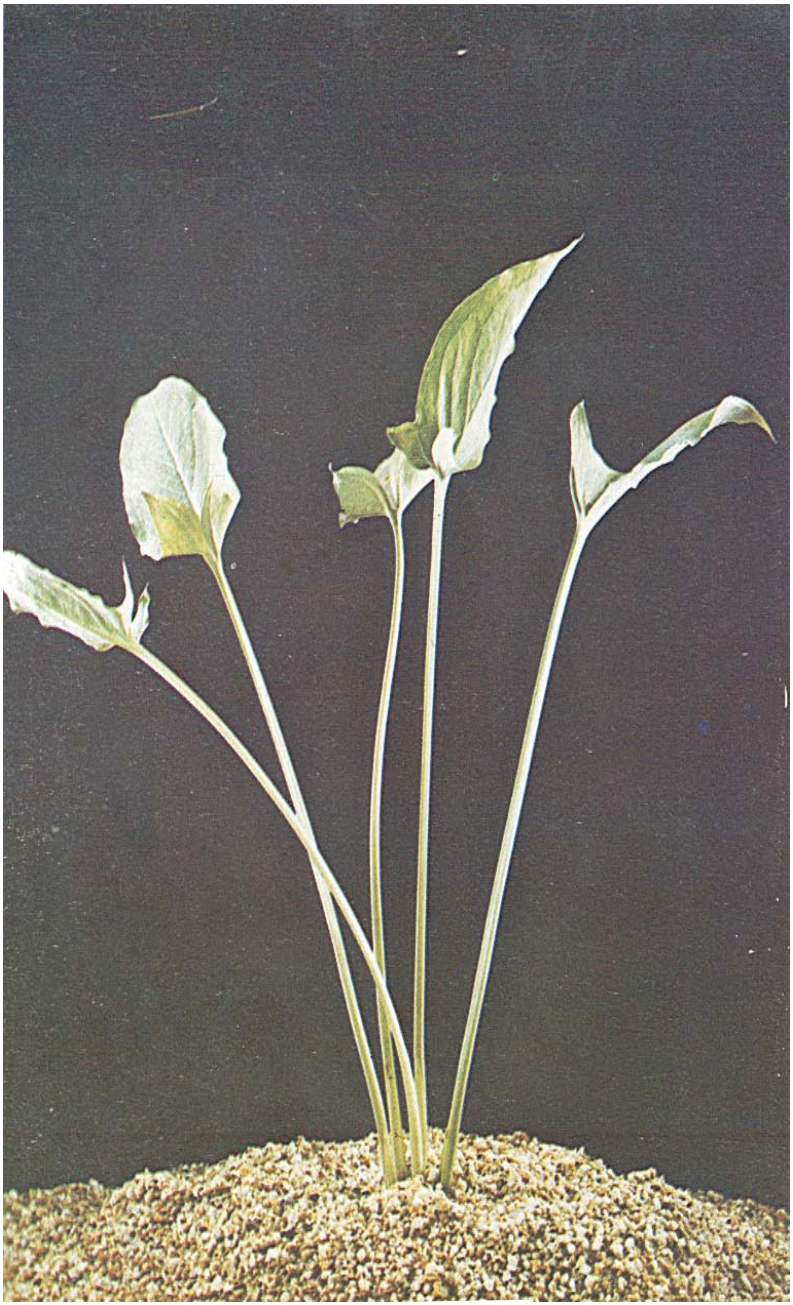
It is best cultivated in shallow water, in well lighted conditions. This species can stand medium temperatures (about 68° F, 20° C) and tolerates a fall in temperature to 59° F (15° C) better than it does an increase. Propagation is by the division of stems, with roots forming below the petiole of each leaf. During winter it should be given additional artificial light or it can hibernate in shallow dishes. Water snails often damage this plant.

There are about 160 species in the genus *Cardamine*. Most of the species are marsh or bog plants. *C. lyrata* Bunge, *C. prosperens* Fischer, and *C. variabilis* Philippi are found growing submersed. *Cardamine rotundifolia* Michx., from North America, is now cultivated in aquariums by the same methods used for *C. lyrata*.

RORIPPA AQUATICA (Eaton) Palmer (Ill. 289, 369)
Syn: *Neobeckia aquatica* Greene, *Armoracea aquatica* (Eaton) Wiegland

The genus *Rorippa* includes 70 species, but according to some authors it is divided into several other genera (*Nasturtium, Neobeckia, Armoracea*). About four species of *Rorippa* are aquatic, but they are usually emersed and not suitable for aquariums.

R. aquatica, from the U.S.A., is the species most often cultivated and is undoubtedly the most beautiful aquarium plant of the family Brassicaceae.



Typhonium flegelliforme.



Minute flowers of *Rorippa aquatica*.

Rorippa aquatica, cultivated emersed.



Living plants are extremely variable. The land form is 7.5 to 12.5 cm and has strikingly odd-pinnate and very deeply incised leaves arranged in a rosette. A stem develops at the time of flowering. Its leaves are alternate; the lower ones are deeply incised, the upper ones entire, with the edges more or less dentate. The flowers are white. *R. aquatica* develops submersed leaves that are quite different from the emersed ones. They are divided into fine narrow thread-like cuttings 25 to 75 mm long, bright green in color. *R. aquatica* can be cultivated in old clean water with a poor planting medium. Its greatest advantage is that it grows exceptionally well in a submersed form in winter, even in tanks with inadequate light. The beauty of its fine leaves equals that of the most beautiful tropical plants, and it belongs without any doubt to the most interesting novelties for aquariums. It does not tolerate overly acid conditions and when grown in shallow aquariums will produce emersed leaves in summer.

SUBULARIA

These plants are annual, tufted, glabrous herbs. The stems are reduced to corm-like structures. The leaves (25 to 75 mm long) are numerous, arranged in a rosette, subulate or linear. Only two species are known growing submersed in pools and lakes. *S. aquatica*, with subulate leaves, is found in North America, northern Europe, and central Asia and can be used for the aquarium only in summer. It is difficult to hibernate. The second species, *S. monticola* A. Br. ex Schweinfl., with linear leaves, comes from the mountains of Uganda, Congo, Kenya, and Tanganyika.

CABOMBACEAE (Fanwort Family)

The family Cabombaceae includes perennial aquatic herbs having floating or submersed leaves. White, yellow, or purple flowers are developed above the water. Only two genera, *Brasenia* and *Cabomba*, are known.

BRASENIA SCHREBERI Gmel. (WATER SHIELD)

Water shield grows in the Americas, from the southern states of the U.S.A. to the tropical area of South America; it occurs also in West Africa, tropical Asia, and in Australia.

From a stiff rhizome, long petioles extend upward, leading into the center of shield-shaped leaves of round or moderately oval form. The blade is 25 to 75 mm long, submersed or floating on the surface; the upper blade is dark brownish green, the lower surface

red-brown. Flowers (which rarely appear in aquaria) are purplish red.

B. schreberi requires a fairly fertile substratum, very soft water of moderately acid reaction and sufficient light. It does poorly in deep water. It is cultivated most easily in the shallows, with adequate light from above.

The plant is interesting on account of its unusual leaves, but as a rule it does not live long and thus it does not belong in aquariums.

CABOMBA (FANWORT)

These are exclusively submersed plants which, when natural waters dry out, may form only two to three emersed leaves. In the emersed stage fanwort can exist only for a limited time.

The stem branches strongly under water and may reach a length of 2 to 3 meters or even more. Submersed leaves are filiform and divided into fine segments of varying size (25 to 50 mm long). During the flowering stage some species develop floating leaves which are oval or linear and about 30 to 40 mm long. The flowers (on the surface) are yellowish, white, or purple-red.

Cabomba is native to the American continents, ranging from the southern U.S.A. to tropical South America. About seven species are known. These species are all very decorative, but are delicate. *Cabomba* does well in old water in a reasonably well lighted aquarium without snails and with few fish, because the stems as well as the leaves are fragile, tender, and damage easily. It requires ordinary aquarium temperatures, about 68° F (20° C), but does not grow at lower temperatures, although it survives them well. The existing literature mentions the most frequently cultivated *Cabomba, C. caroliniana*, as having floating sagittate leaves and white flowers that are clear yellow at the center. *C. aquatica* comes from the tropical area of the Amazon River and evidently has not yet been imported to Europe, its name appearing in the literature by mistake. Authors are wrong in assuming that it is possible to determine individual species according to the width of the leaf segments. The reliable determination of cultivated species depend entirely on the flower structure. It appears that only the three following species are cultivated in aquariums.

CABOMBA CAROLINIANA A. Gray (Ill. 292, 293, 296)

This species from the southern part of the United States also extends to South America. The leaves are divided into narrow segments. The floating leaves are sagittate and the flowers are white,



Cabomba caroliniana var. *multipartita*.



Cabomba caroliniana var. *paucipartita.*



Flower of
Cabomba caroliniana.

yellow in the center. Leaf blades are 30 to 40 mm long and up to 60 mm wide. The flower is star-shaped; petals (crown leaflets) are narrow, not covering each other.

C. caroliniana is not a typically tropical species. It endures a relatively shorter day in winter and is able to winter even with a small amount of light. It is not difficult to cultivate and therefore is used frequently by aquarists.

This plant exists in several natural and horticultural forms, the best known of which is *C. caroliniana* var. *multipartita* Hort. It is a horticultural form, obtained by selection, which has abundant leaves (75 mm wide) with a greater number of segments.

C. caroliniana var. *paucipartita* Van. Ramsh. et Florsch. is, on the other hand, very delicate in appearance. The leaves have only a few thin segments. It is of little value for aquariums.

C. caroliniana var. *pulcherrima* Harper differs from the preceding species in having a more abundant foliage and purple-red stem and leaves (a most beautiful plant). It is rarely found in European tanks, though quite capable of tolerating a rather shady environment.

CABOMBA AUSTRALIS Speg. (Ill. , 337)

C. australis is found in southern Brazil, Uruguay, Paraguay, and Argentina. It occurs between the southern subtropical and the temperate zones. It needs the same attention as *C. caroliniana* and is probably unrecognized in the aquarium of aquarists until the time of flowering. The leaves are rather small, up to 20 to 30 mm wide and 50 mm long; the leaf segments are medium in size, about 0.5 mm wide. The flowers are clear yellow with a striking orange spot at the base. It differs from other species in the shape of the flowers, the crown leaflets being egg-shaped and so broad that they overlap each other; the flowers are not star-shaped, but are round and slightly campanulate.

CABOMBA PIAUHYENSIS Gardner (Ill. 296, 325)

This species is distributed over a large area extending from Central America to South America, reaching to the area of the Amazon River. This is a typical tropical species that grows slowly and is fragile and also sensitive to algae. It can only be cultivated in clean water without snails, which often damage it. *C. piauhyensis* is sensitive to a short winter day and requires extra light hours, otherwise it will die. It roots poorly and slowly. Newly imported plants coming from natural environments have bright red to purple-violet stems and leaves. In aquariums this wonderful

coloring usually disappears after a while. The plants will keep the red-brown color only in very well illuminated places. The flowers, situated on 2.5 cm pedicels, are star-shaped, purple-red to violet, with a yellow spot in the center.

CERATOPHYLLACEAE (Hornwort Family)

The family Ceratophyllaceae is composed exclusively of perennial plants and includes only the genus *Ceratophyllum* (foxtail) with two species. Some authors list up to 30 species, which are probably mostly local varieties. These are submersed plants with only their tips reaching the surface. The leaves, arranged in whorls, are forked. True roots are absent and are replaced by short "rhizoids."

CERATOPHYLLUM DEMERSUM L. (Ill. 297)

C. demersum is distributed all over the world. The leaves have two-forked divisions. This species is commonly found in backwaters and pools of both lowland and hill countries and prefers swampy soils. Propagation is mainly by stem breakage.

CERATOPHYLLUM SUBMERSUM L.

This plant is found throughout the world. However, in the temperate zone it is found only in the lowlands of the warmer regions, being absent over wide areas. It is found more frequently in slightly brackish waters, where *C. demersum* is not present. It differs from *C. demersum* in having three-pronged leaves.

Plants of both species originating from the temperate zone are not suitable for aquariums. They become spindly and the distance between the whorls of the leaves increases as much as five times while the leaves become thin and short, so the plants lose their natural decorative character. The plant usually dies in the summer. In recent years a species of *Ceratophyllum* has reached the European market from Cuba. Its whorls are very abundant and dense, even when maintained in a warm aquarium. It is a very decorative plant.

CLUSIACEAE (Guttiferae)

This family, with about 40 genera and about 100 species, contains only one unique water plant.

HYPERICUM ELODES L.

This plant can be found growing in bogs and marshes of western Europe and is rarely cultivated in aquariums. The leaves are opposite, rounded, sessile, and partly surround the prostrate stem.



Cabomba piauhyensis.

Flowers of *Cabomba caroliniana* var. *pulcherrima.* Photo by T.J. Horeman.




Ceratophyllum demersum.

It propagates easily by rooting part of the stems with leaves. For its cultivation, old neutral water that can be medium hard is used. *H. elodes* must receive the maximum amount of illumination in winter, otherwise it will die.

COMMELINACEAE

Many representatives of the family Commelinaceae are commonly cultivated as indoor plants—*Tradescantia*, *Commelina*, *Cyanotis*, etc. They are known to be extremely hardy and simple, rooting easily in tanks with tap water. Many experiments undertaken to acclimate these plants under water have so far produced negative results. There is a species found in nature, *Murdannia blumei* (Hassk.) Brenan, which is a weed in the ricefields of Asia. Plants of an undetermined species of the genus *Floscopa* are also currently being imported.

FLOSCOPA (Ill. 301)

Emersed stems of *Floscopa* plants are prostrate, rooting in many places. The alternate leaves are sessile with inconspicuous fine hairs, lanceolate, and about 50 to 75 mm long. Vegetative tips (10 to 15 cm long) with five to six leaves can be transplanted under water. They root quickly; the fine hairs disappear, blades turn light green and conspicuously extend up to a length of 10 to 15 cm. Being most decorative, *Floscopa* is among the very attractive novelties of recent time.

CRASSULACEAE (Orpine or Crassula Family)

This family consists mostly of drought-loving herbs, undershrubs and bushes. Only a very small percentage of about 1500 species live in a moist medium and are able to grow amphibiously.

CRASSULA (*TILLAEA*) (Ill. 300)

The genus *Crassula*, with about 300 species, comprises mainly succulent herbs. Only a few species, with creeping floating stems, are found in wet places and may tolerate long periods of submergence. *Crassula aquatica* (L.) Schonl. from Europe and *C. vaillantii* (Willd.) from the Mediterranean area and the United States are annual plants. They are not suitable for the aquarium. *C. helmsii* Kirk from New Zealand and *C. bonariensis* (DC.) Camb. from South America are commonly cultivated in indoor tanks. These are always perennial and fit for aquariums, although they are not very popular.

Species of this genus reach a height of 40 cm. The leaves are about 15 mm long and 1 mm wide, needle-shaped, opposite and

arranged cross-wise. The land form has distinctly shorter leaves. Minute reddish or white flowers develop at the axil of the leaves.

Crassula plants are best cultivated in well illuminated situations. In other respects (composition of water, temperature) they are not particular. They do not flower when submersed and propagate by stem division. These plants are not too decorative.

CYPERACEAE (Sedge Family)

This family contains perennial, or more rarely annual, plants. Compound inflorescences of the most varied types are present. The family Cyperaceae contains 60 genera with 3,700 species distributed all over the globe from the tropics to the Arctic regions, including high mountain habitats. Various species are confined to special locations (sand, rocks, steppes, woods, meadows); many grow in marshy to bankside conditions but are adapted solely to an amphibious life and can live under water only temporarily.

CYPERUS (CYPRESS GRASS)

This genus is distributed mainly in the tropical and subtropical zones of the world. Some more resistant species grow even in the temperate zones. They are absent only from high ground. These are low, medium, and tall plants, usually with a leaved culm. Altogether more than 900 species are known; some of them are commonly cultivated in greenhouses and as indoor plants. The best known species is *C. alternifolius* L. from Madagascar, known by the incorrect name "*papyrus*." The real C. *papyrus* L. inhabits the Mediterranean area (principally Egypt) and reaches a height of 1.2 to 3.0 meters; in ancient times a paper was made from it.

Almost all the perennial species can be used in terrariums and paludariums. Since the majority of *Cyperus* species grow in moist, periodically flooded places, some of them can be cultivated as aquatic plants at least temporarily.

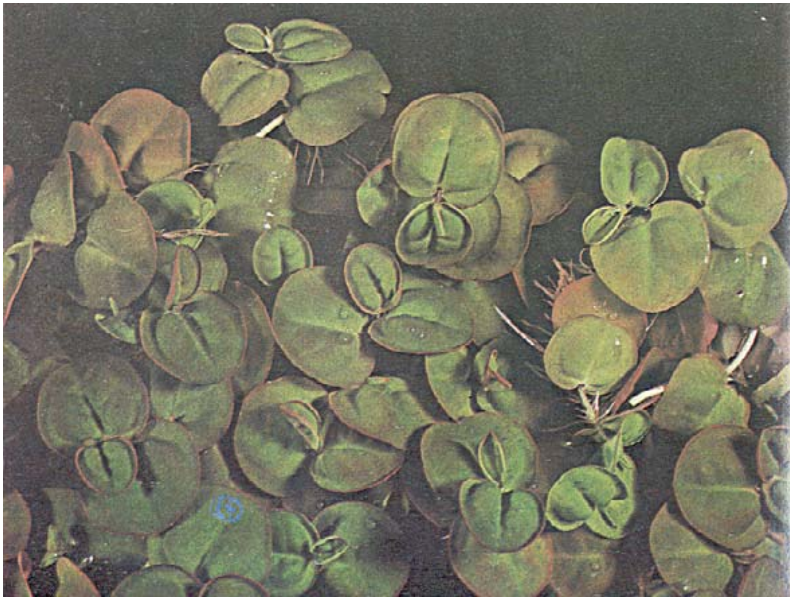
CYPERUS ERAGROSTIS L. (Ill. 302)

Of more than 100 species tested by the senior author for underwater cultivation, this species has been found to be the best. It forms a white rhizome (up to 7 mm thick), from the lower part of which a sparsely leaved culm develops with a typical fan of linear leaves at the upper end. In the emersed state in terrariums it flowers readily and produces a great number of fertile seeds. Under water this species reaches a height of 20 to 30 cm and is propagated by buds on the rhizome, which produces a group of very decorative plants of unequal sizes.



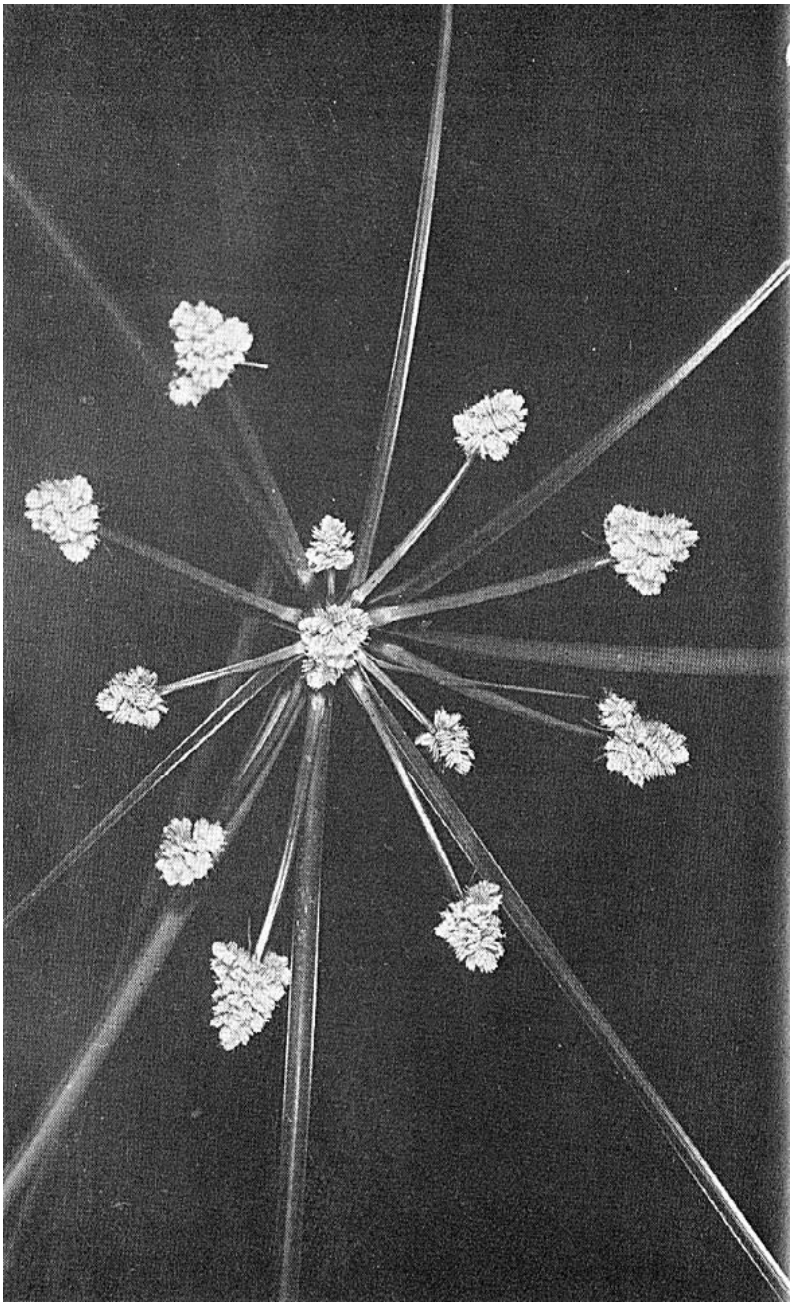
Crassula aquatica.

Phyllanthus fluitans.





Floscopa species.



Bird's eye view of the terminal rosette of leaves and flowers of *Cyperus eragrostis*.

It requires a sandy substrate, generous daylight, and a temperature of about 68° F (20° C); it can stand lower temperatures (down to 50° F or 10° C) for a short while.

ELEOCHARIS (SPIKE RUSH)

These plants (minute to medium height) are found in marshes, on the banks of rivers, and on the bottom of stagnant or slow moving waters. The genus consists of more than 200 species growing all over the world, from the tropics to the Arctic. Many of them can withstand great fluctuations in temperature and are suitable for both coldwater and tropical tanks. In appearance they differ greatly from the majority of aquarium plants, so they form an appropriate complement to the specimens usually maintained.

They are content with a very poor planting medium but require a fair amount of light, especially if they are to be kept in good condition through the winter months.

Many native and foreign species, such as *E. palustris* (L.) R. et S., *E. obtusa* (Willd.) Schult., etc., can be cultivated in aquariums. They are more robust and often form tufts, but drop their leaves for the winter period. The following two species are the most suitable for aquariums.

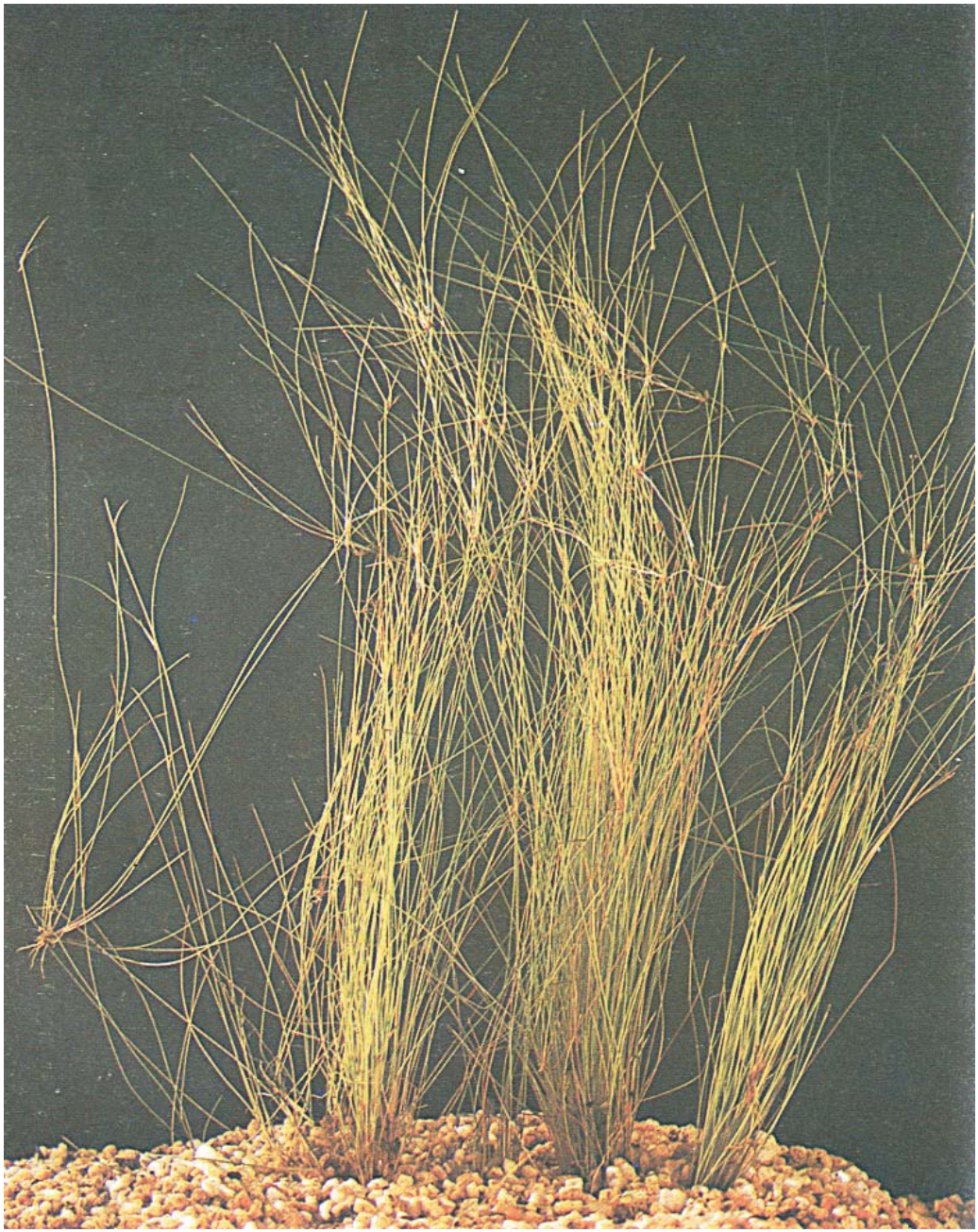
ELEOCHARIS ACICULARIS (L.) R. et Sch.

Hair grass grows in the temperate, subtropical, and tropical zones of the world, excluding Africa. It is found on the sandy banks of rivers and lakes and is as a rule amphibious. The rhizome is thread-like, creeping, with long rooting runners forming minute tufts of delicate, slender, light green stems. The submersed stems are from 40 to 60 cm tall; the culms produced by land forms are shorter and the dense rootstock creates a conspicuous carpet. The emersed form will flower if kept in containers with a thin layer (25 mm) of earth.

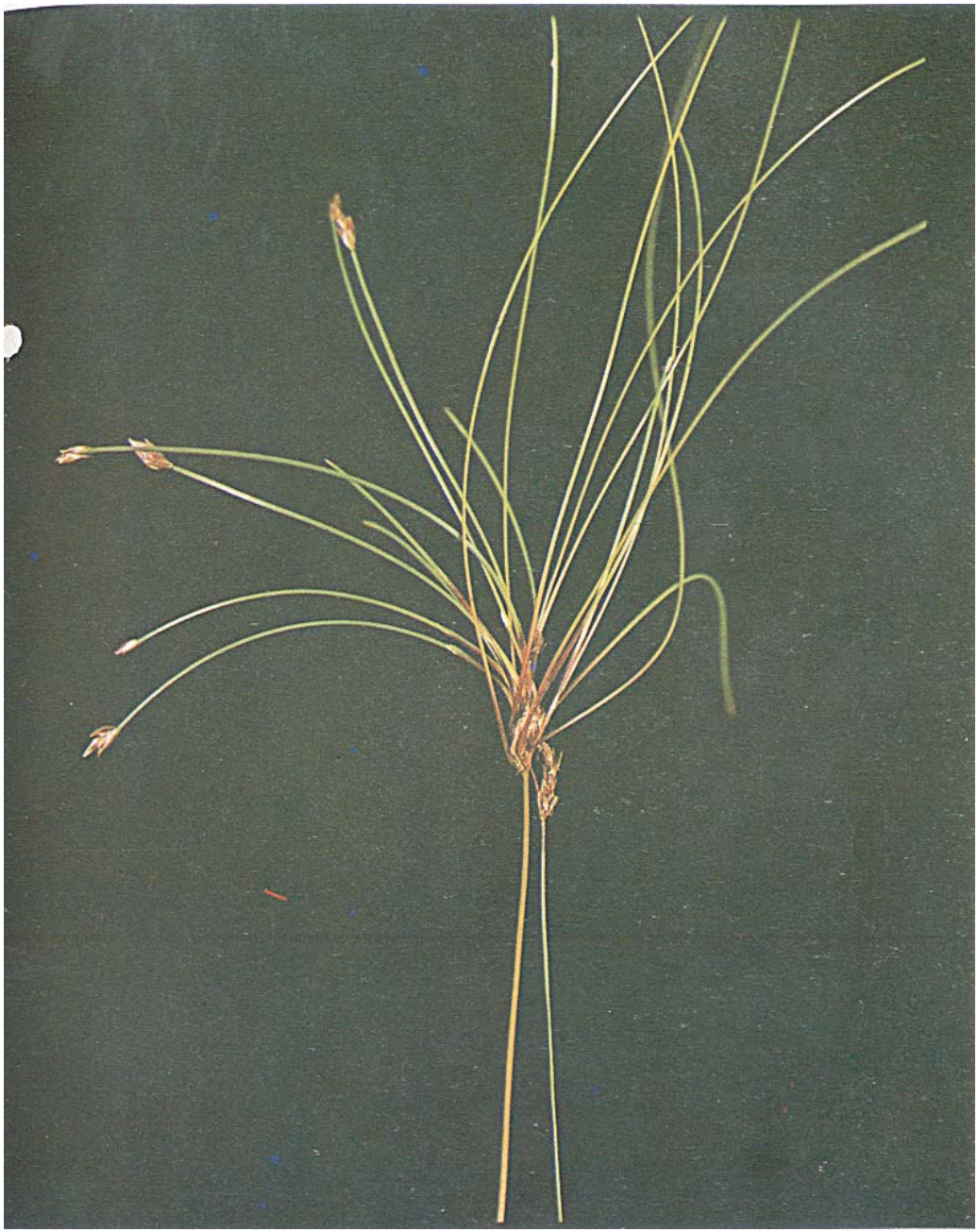
In the aquarium the plant should be cultivated in a poor sandy medium under fairly good illumination; if the tank is given additional artificial light in winter, the plant grows all through the year. It is not particular with regard to temperature (50° to 77° F, 10° to 25° C). Propagation is by root runners and nutlets; in deeper waters it rarely forms rooting bud-plants that are arranged in tiers, one series above the other. This plant is easily obtained from our waters and marshes.

ELEOCHARIS VIVIPARA Link (= *E. prolifera*)

E. vivipara comes from the warm southern parts of the United States, growing in situations similar to those where *E. acicularis* is



Eleocharis minima, submersed plant.



Flowering *Eleocharis minima*.

found, but in comparison to the latter it is better adapted to submersed growth. Under water it forms long and slender stems with groups of fine linear leaves that are arranged in linear whorls, one above the other (rather like upturned umbrellas). On each stem there are ten to fifteen whorls, each with roots at the base; by dividing the stem into individual whorls the plant is readily propagated.

Its cultivation requires the same conditions as those of the preceding species: a sandy soil and plenty of light. Temperature requirements are not too critical. If kept in tanks without additional warmth it often dies in winter.

A similar plant cultivated in aquariums is *Eleocharis minima* from South America. Both species are hardly distinguishable when cultivated submersed in the aquarium. (Ill. 304-305)

ISOLEPIS

Of about 60 species of *Isolepis* growing in shallow water, only *I. setacea* is commonly cultivated in aquariums. Under water it resembles *Eleocharis acicularis*. Emersed, flowering plants are distinguished according to the position of the inflorescence. In *I. setacea* it is located a short distance before the tip of the stem, while in *E. acicularis* it is exactly at the tip of the stem. Cultivation of both plants in aquariums is the same.

DROSERACEAE (Sundew Family)

This family is represented mostly by perennial herbs, of which only the genus *Aldrovanda* is bound with an aquatic medium. The genera *Drosera* and *Dionaea* grow on peat soils, *Drosophyllum* on dry soil. It is a family of typically carnivorous plants. The aquatic genus *Aldrovanda* contains a single species, *A. vesiculosa*.

ALDROVANDA VESICULOSA L.

This European perennial plant grows on the surface layer of water. It has no roots, only a thin stem which is 25 to 100 mm long. Leaves are arranged in whorls, and their round blades are equipped with large bristles. On the upper surface of the blade there are numerous digestive glands which absorb the captured minute animal organisms. Flowers are greenish white. The fruit is a pod with ten black seeds.

A. vesiculosa is rarely seen, is not a popular plant, and is difficult to cultivate in aquariums, where it grows very slowly and soon dies. The carnivorous embossments are sufficiently large to endanger both the fish fry and their living crustacean food. Medium to low temperatures and acid water are required. The plant is

propagated by stem division and winter buds.

ELATINACEAE (Waterwort Family)

The family Elatinaceae has two genera, *Bergia* with about twenty species and *Elatine* with about twelve species; both genera contain amphibious plants. Some species are able to survive under water for a long time and are useful in aquariums; others flower readily and form seeds capable of germinating.

ELATINE (WATERWORT)

Elatine is suitable only for aquariums. In terrariums and paludariums the plants are basically annuals; even with sufficient moisture they flower and then die. *Elatine* has been cultivated recently, but only very rarely. Often mistakenly offered in the shops under the name "Elatine" is *Lilaeopsis lacustris* or *Lilaeopsis novae-zealandiae* (see the family Apiaceae).

ELATINE HYDROPIPER L.

In the aquarium it does not thrive as successfully as the next species. Although it is an annual, in submersed conditions it lasts longer.

E. hydropiper should be cultivated under conditions similar to those used with *E. macropoda*, shallow water with plenty of light; it is not quite so particular with respect to the type of soil. As a rule it hibernates well. Because of the very feeble root system, the plants are often pulled loose, especially in tanks with fish foraging close to the bottom.

Other species are less suitable for aquariums and hibernate badly. Examples are *E. hexandra* (Lap. Dc.) with six stamens and *E. triandra* Schkuhr. with three stamens. Both species are rare in nature and are mostly annual.

ELATINE MACROPODA Guss.

This plant is distributed through southern France, Sicily, Malta, Spain, Algeria, and Morocco. In nature it is an annual, 25 to 50 mm tall with a creeping, well branched stem.

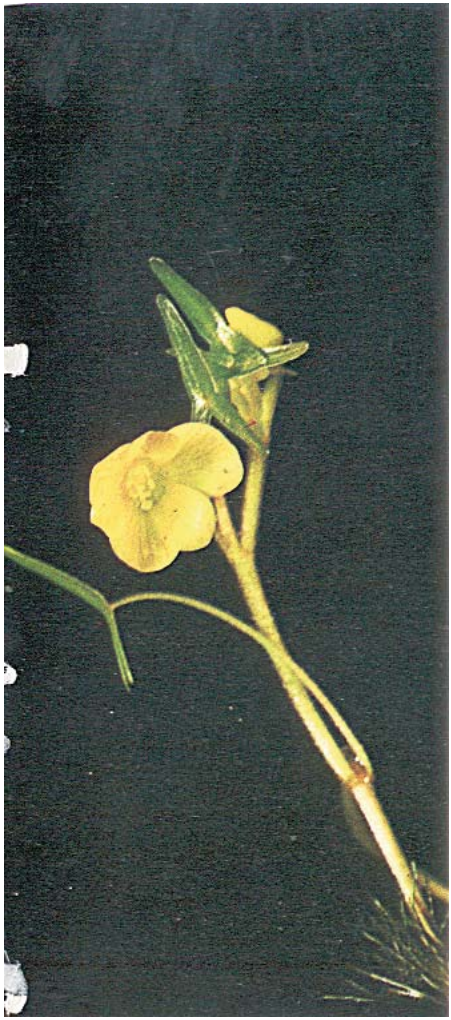
Submersed forms are perennial in aquariums, take root abundantly, and form characteristic tufts of prostrate stems with spatulate leaves 10 to 18 cm long and 10 to 30 mm wide; the leaves are light green in color.

E. macropoda grows faster than all other species of *Elatine* and forms rich carpets close to the bottom of the tank. The plant requires temperatures from 55° to 77° F (13° to 25° C). It is not particular in other respects, but it does not stand lime salts and does well only in shallow water. It hibernates readily and its root



Myriophyllum aquaticum, submersed form.





Bright yellow inflorescence of an unidentified *Cabomba*.



Cabomba australis.

veins. The plant is dioecious; female plants are the ones most generally present in aquariums.

This tall plant requires a large (deep) aquarium where it can develop properly. It is not exacting with respect to the composition of the substrate and water, but needs a higher temperature than the other common species of *Vallisneria* (above 68° F, 20° C). Plants blossom throughout the summer but do not produce seeds and are propagated vegetatively by separating young plants from the rhizome runners. Propagation is much slower than that of smaller species of *Vallisneria*. If the aquarist wants to obtain a greater number of individuals, he has to replant them repeatedly from March to August. Two to three weeks after being established, one parent plant produces two to three root runners on which three to seven new plants arise; after this, usually no further runners appear. As soon as the runners have grown sufficiently strong they are uprooted, together with the parent plant, and planted again. Propagation then continues.

VALLISNERIA GIGANTEA var. *RUBRA* Hort.

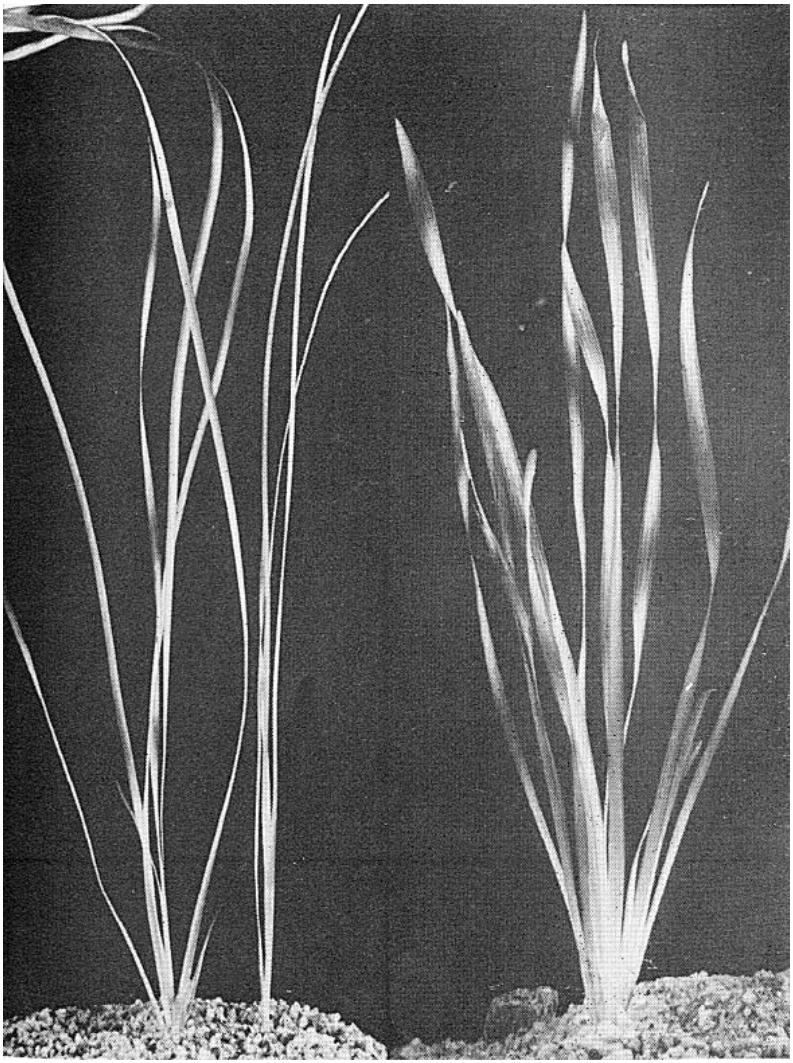
Var. *rubra* has been imported only lately. It resembles the preceding green form, but its leaves are red-brown with distinct dark veins. It is not known whether it is an undescribed natural variety, a new species, or a horticultural form obtained by selection. As alleged by importers it occurs in nature in association with the initial species, *V. gigantea*.

VALLISNERIA PORTUGALENSIS Hort. (Ill. 332)

The origin of this plant is unknown; it is probably some variety of *V. denseserrulata*. In the aquarium the leaves are 30 to 40 cm long (longer than those of *V. americana*), up to 10 to 15 mm wide, and coiled five to six times; margins are lighter and undulate or curled. It tolerates slightly acid water and half shade and can be cultivated with *Cryptocoryne* species.

VALLISNERIA SPIRALIS L.

V. spiralis has been recorded throughout the tropical zones, but it occurs mainly in the subtropical areas of the world; it also appears in the temperate zone of Europe (Italy and France). The character of the plant is the same as that of *V. gigantea*. Leaves are bright green, ribbon-shaped, 120 cm long or even longer, and 5 to 12 mm wide, usually with five longitudinal veins. The leaves are straight only in young plants; upon reaching a length of 10 to 15 cm they are generally moderately coiled once or thrice along their length.



Vallisneria asiatica. *Vallisneria americana.*



Lobelia splendens.



Not all species of *Lemna* found in many ponds are suited for the aquarium. Photo by C.O. Masters.

Mayaca growing emersed on swampy ground in Brazil. Photo by T.J. Horeman.



This species grows in any normal aquarium conditions and is the most common plant in aquariums in Europe. It is not exacting as to the composition of the planting medium or water. If given a generous light it propagates quickly and soon fills up the whole aquarium with a dense growth.

VALLISNERIA TORTISSIMA Hort. (Ill. 333)

The origin of this most decorative *Vallisneria* is unknown. The leaves with a length of 40 to 50 cm are usually only 5 mm wide and are coiled fifteen to twenty-five times. This plant is very resistant and grows in the same conditions as the common *V. spiralis.*

LEMNACEAE (Duckweed Family)

The family Lemnaceae is represented for the most part by species that float on the surface of the water. They represent the smallest of the monocotyledonous plants. The body of the plant is formed by a single flat internode with a rootlet.

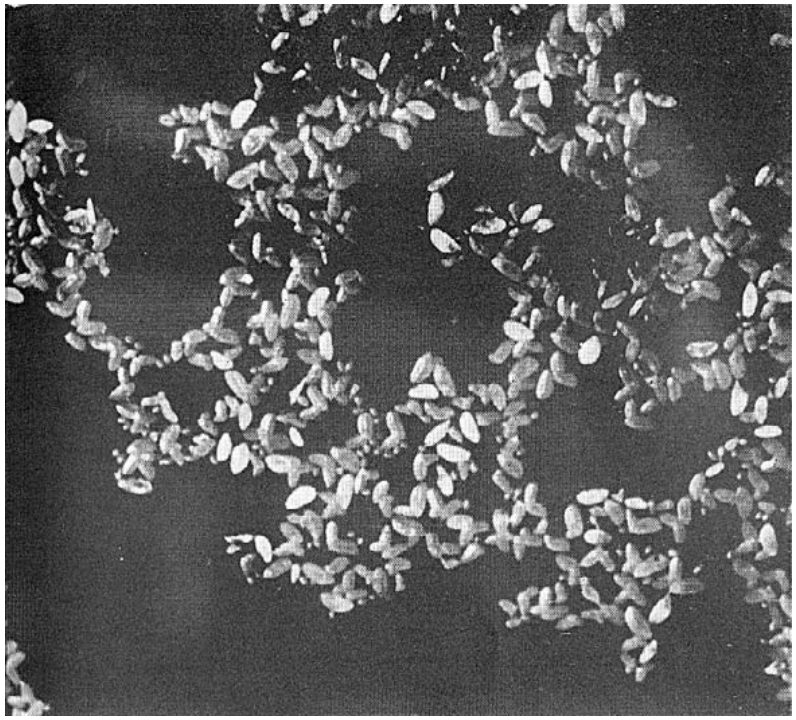
Minute flowers are produced very rarely (even in nature) so that the plants are virtually never propagated from seeds. Vegetative propagation is the most common method of reproduction and in good conditions a new plant may arise every thirty to forty hours; thus it is clearly capable of speedy reproduction.

The family is distributed from the tropics to the temperate zones and contains the genera *Lemna* (duckweed), *Spirodela* (great duckweed,) *Wolffia* (watermeal), and *Wolfiella*; altogether there are about thirty species.

Since they reproduce very quickly they are not suitable for aquariums, covering the surface with a closely intermeshed growth so that the space below is deeply shaded. If the surface needs to be shaded there are other, taller plants at hand whose growth can be regulated. An aquarium infested by duckweed can not be cleaned properly because the individual plantlets sink and get caught in the tangle of other plants at the bottom, where they escape our notice. Later they rise again and create new colonies. For this reason they are regarded as a weed in the aquarium and they should be destroyed as soon as possible if they happen to be brought in accidentally along with fish food or other plants. Only one species, *Lemna trisulca*, is of any use in the aquarium, while the other species can be used for covering water areas in terrariums and paludariums.

LEMNA (DUCKWEED) (Ill. 25, 341)

The genus *Lemna* includes nine species which have flat, exceptionally swollen internodes with a single root. They are known to reproduce vegetatively very fast.



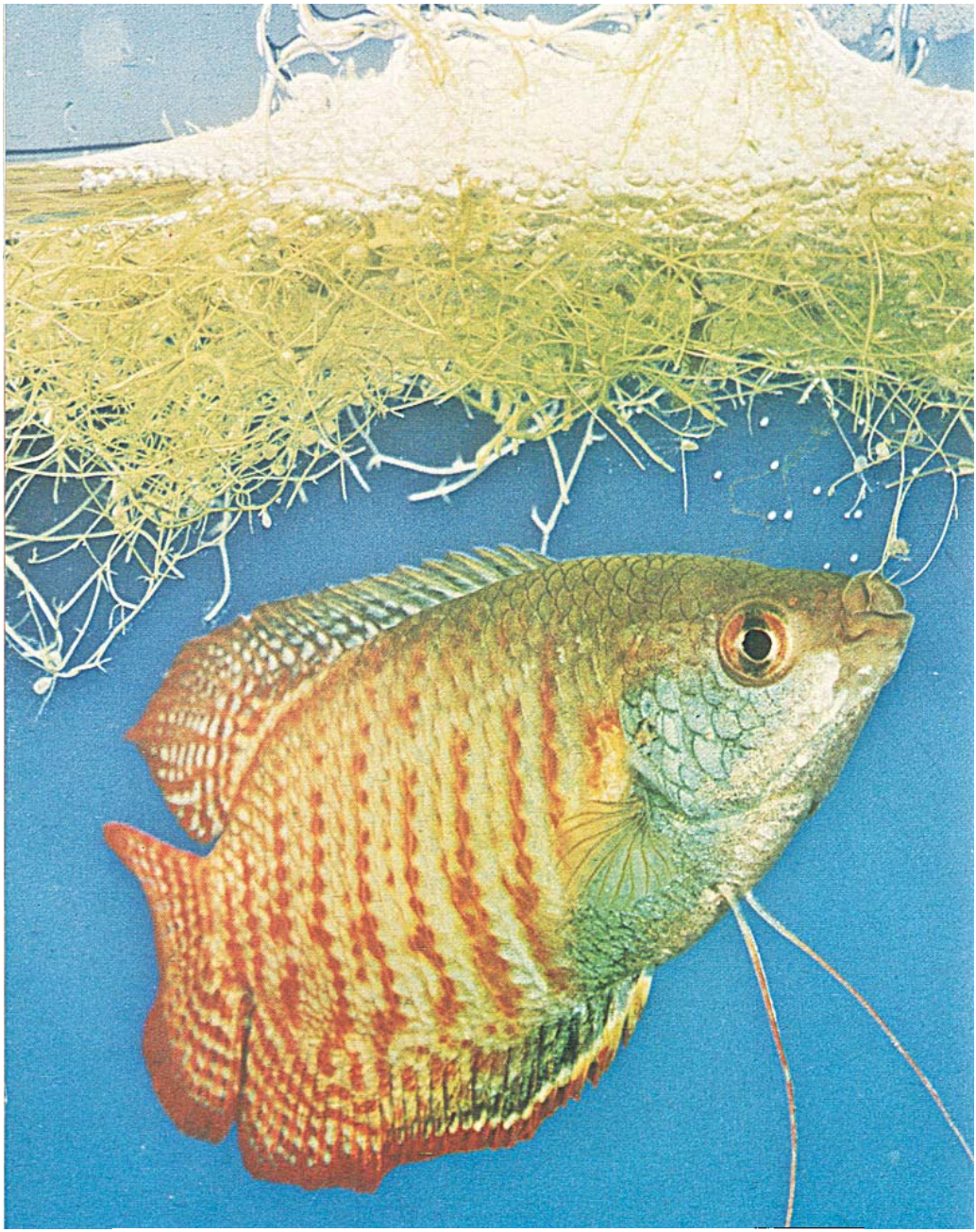
Very tiny *Wolffia* scattered among much larger *Lemna*, growing together in a pond. Photo by Dr. D. Sculthorpe.

LEMNA TRISULCA L. (CHAIN OF STARS or IVY-LEAVED DUCKWEED)

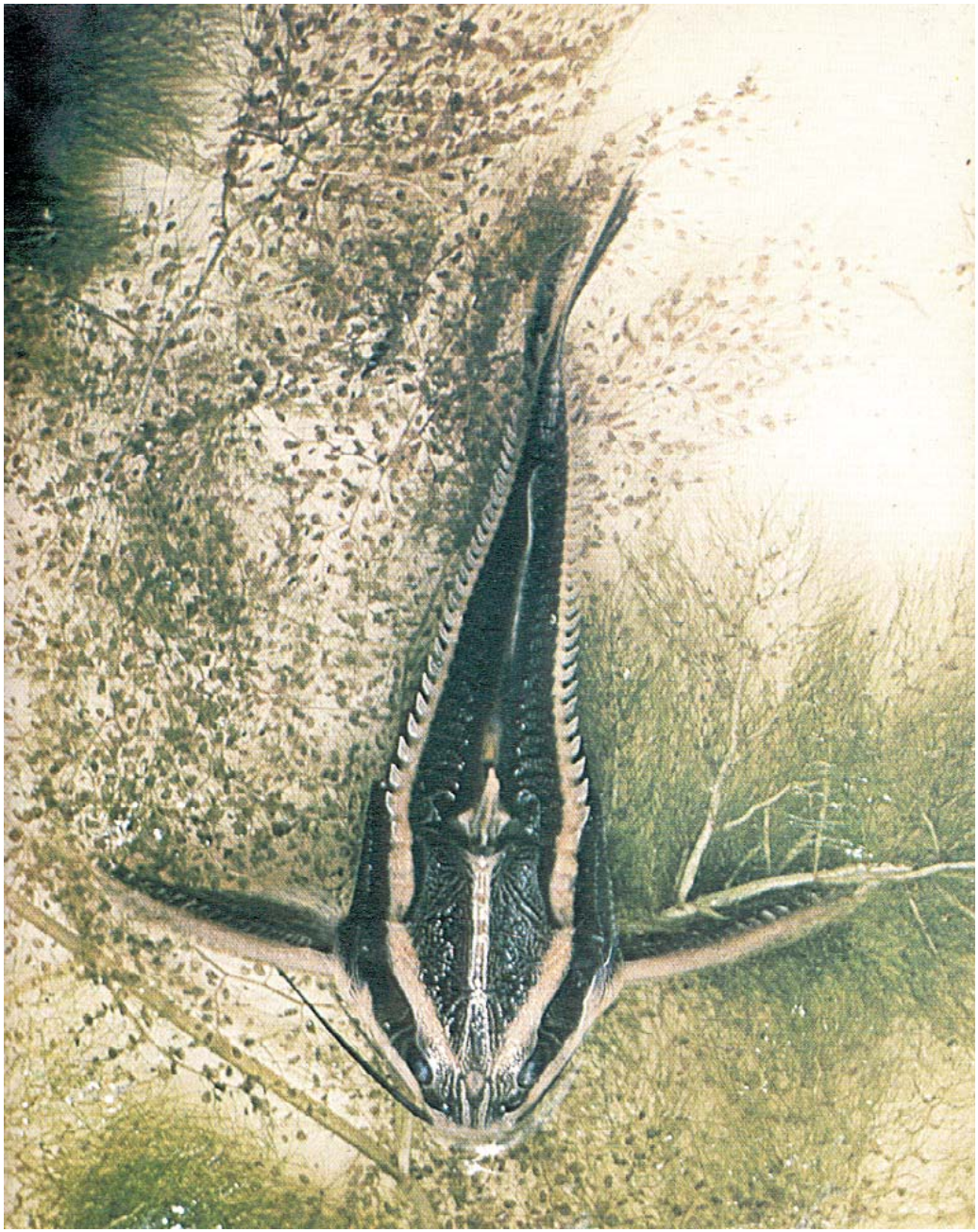
This species is found all over the world. The translucent internodes are ovately lanceolate to lanceolate. Four to fifteen plants are connected to each other by narrow stalks so that they form pronged, branching, grass-green colonies. In nature they live on the surface of the water or in a submersed form attached to other plants. It is the only species of Lemnaceae suitable for use in the aquarium. With regard to external conditions it is not very exacting; plants hibernate readily at temperatures around 68° F (20° C).

WOLFFIA (WATERMEAL) (Ill. 343)

The smallest flowering plant in the world is found in the genus *Wolffia*. The body is only 1 mm long, floating on the surface of the water, without roots. The individual plantlets are hardly visible, but they can form a solid cover on the surface of the water.



A male *Colisa lalia* guarding the bubblenest situated in a clump of bladderwort (*Utricularia*). Photo by H.J. Richter.



An armored catfish (*Acanthodoras spinosissimus*) resting on top of a cluster of *Utricularia*. Note the conspicuous bladders on many of the branches. Photo by Dr. Herbert R. Axelrod.

LENTIBULARIACEAE (Bladderwort Family)

Water, marsh, and land species whose leaves are adapted for catching minute animals represent this family. There are four genera altogether, and not all the species grow submersed.

UTRICULARIA (BLADDERWORT) (Ill. 11, 70, 344, 345, 348)

Some species of bladderwort are tropical and subtropical plants which grow as epiphytes entwined on trees and bushes and as land forms. Altogether about 260 species are known which are distributed mainly in the tropics. The aquatic *Utricularia* species of the temperate zone are mostly annual, but those from the tropics are annual and perennial as well. The leaves are filiform to hair-like segments with minute snapping bladders, some of the leaves projecting above the surface. In nature the plants flower irregularly, while in aquariums they flower very rarely and consequently are identified only with difficulty. Only the tropical species are fit for the aquarium.

UTRICULARIA EXOLETA R. Brown

In Europe this species is found only in Portugal, but otherwise it occurs in North Africa, Ethiopia, tropical Africa, tropical Asia, and in Australia. Small leaves with very minute bladders are characteristic for this species. The floral stalk is 2.5 to 10 cm long and the flowers are white or yellow, but it does not flower in the aquarium.

U. exoleta is very resistant and can withstand bright light as well as shaded conditions. It is not particular with regard to the type of water, but does best in a soft, moderately acid medium. A great range of temperatures is tolerated; it grows well at 68° to 86° F, 18° to 30° C. Bladders are developed in water containing minute animals, but the bladders are too small to capture fish fry. Dense tangles of delicate stems which grow very fast are formed. By dividing the always rootless stems, the plant is propagated.

In recent years some bigger, undetermined species have been imported. These are cultivated in the same way as *U. exoleta*.

LILIACEAE

Many of the well known garden plants, such as the tulip, snowdrop, lily, and others are included in this family. Although many representatives occur in rather moist places, these plants have not until now been cultivated in aquariums. It is only recently that the two following genera have been imported from tropical Asia to Europe.

CHLOROPHYTUM BICHETII Backer (Ill. 400)

This plant (native to Malaya) has twenty to thirty leaves originating from a rhizome which has whitish underground bulblets that are pointed or elliptical at the tips and 10 to 15 mm long. The leaves are strap-like, narrowed at both ends, and green with parallel nerves that are very distinct. Leaf margins are trimmed with golden yellow. Flowers are white, about 10 mm long, and resemble tiny lilies.

Chlorophytum propagates by producing tufts that can be easily separated from each other. Propagation is effective only in emersed cultivation. Plants which are transplanted under water acclimatize quickly and without difficulty. They are not sensitive to changes in the pH, but do not tolerate new water. Growth under water is rather slow. This plant is a promising aquarium novelty.

OPHIOPOGON (Ill. 350)

Leaves of *Ophiopogon* grow arranged in a row from the roots, not in rosettes. They are stiff, leathery, strap-like, bending in an arch on both sides, and green with distinctly protruding dark and parallel nerves.

Recently imported is *O. japonicus* Ker-Gawler, which reaches the height of 7.5 to 10 cm, and another most beautiful but still undetermined species which grows to a height of 25 to 35 cm.

Both species propagate emersed from long root runners or from short rhizome runners and can be transplanted under water easily. These species will certainly become a popular addition to the list of hardy aquarium plants.

LIMNOCHARATICEAE

This relatively small family contains just four genera. The genus *Limnocharis* (with two species) is not used in aquatics, the plants being unable to grow permanently under water. The same is valid for the genus *Tenagocharis*. Only *Hydrocleis* can be cultivated in indoor aquariums. This genus with nine species is very decorative and widely cultivated. The plants are usually partly floating and partly rooted.

HYDROCLEIS NYMPHOIDES (Humb. et Bonpl.) Buch.

H. nymphoides is found all over tropical South America and is often cultivated as a decorative aquatic greenhouse plant. It is often confused with similar species of the genus *Nymphoides* of the family Menyanthaceae.



Flower of *Utricularia* species from Guyana, South America. Photo by T.J. Horeman.

Utricularia species with beautiful purple flowers from Guyana, South America. Photo by T.J. Horeman.

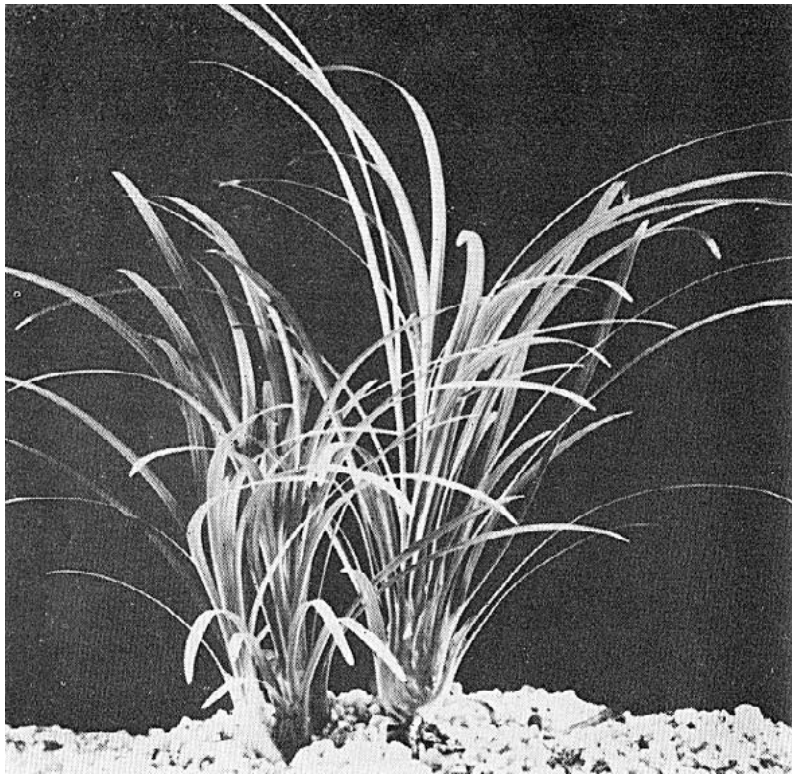




Two species of *Nymphoides: N. peltata* (the single yellow flower on the left) and *N. indica* (white flowers). Photo by C.O. Masters.

Flower and bud of *Barclaya longifolia*. Photo by T.J. Horeman.





Ophiopogon japonicus.

Hydrocleis possesses floating leaves and is seldom used in aquariums. It blossoms very readily, however, and the very beautiful flowers, up to 50 mm in diameter, campanulate, and bright yellow in color, are good for decorating aquariums.

The fast growing rhizome has creeping shoots that root in the substrate and develop long, tubular petioles (up to 7.5 mm thick), bearing at first submersed, later floating, blades about 7.5 to 10 cm long and 50 to 75 mm wide. These blades are ovate, cordate at the base, and leather-like; the upper surface is glossy grass-green, the lower surface light green. The flowers develop at the nodes of the floral stalk at the same time as the new leaves that root. In favorable conditions it flowers from spring until the end of summer.

H. nymphoides is cultivated in a rich soil in a well lit aquarium with soft water. The surface of the water should be generously supplied with light. *Hydrocleis* is content with indoor temperatures.

LOBELIACEAE (Lobelia Family)

This family contains about thirty genera including ten genera that are aquatic. Only *Lobelia* is cultivated in aquariums. There are about 365 species in this genus; many of the species are found in wet or occasionally flooded regions.

L. dortmanna, a typical submersed species, occurs in the acid lakes of North America and sub-Arctic Europe. It has a rosette of submersed leaves and an emersed inflorescence. This plant is often cited in aquatic literature, but it is not cultivated and not suitable for aquariums. Other species, such as *L. paludosa* Nutt. from North America, *L. aquatica* Cham. from South America, and *L. asiatica* Lam. from Southeast Asia, are also not suitable for indoor tanks.

Commonly cultivated in aquariums are two red flowering, paludal species (other *Lobelia* species have blue or white flowers).

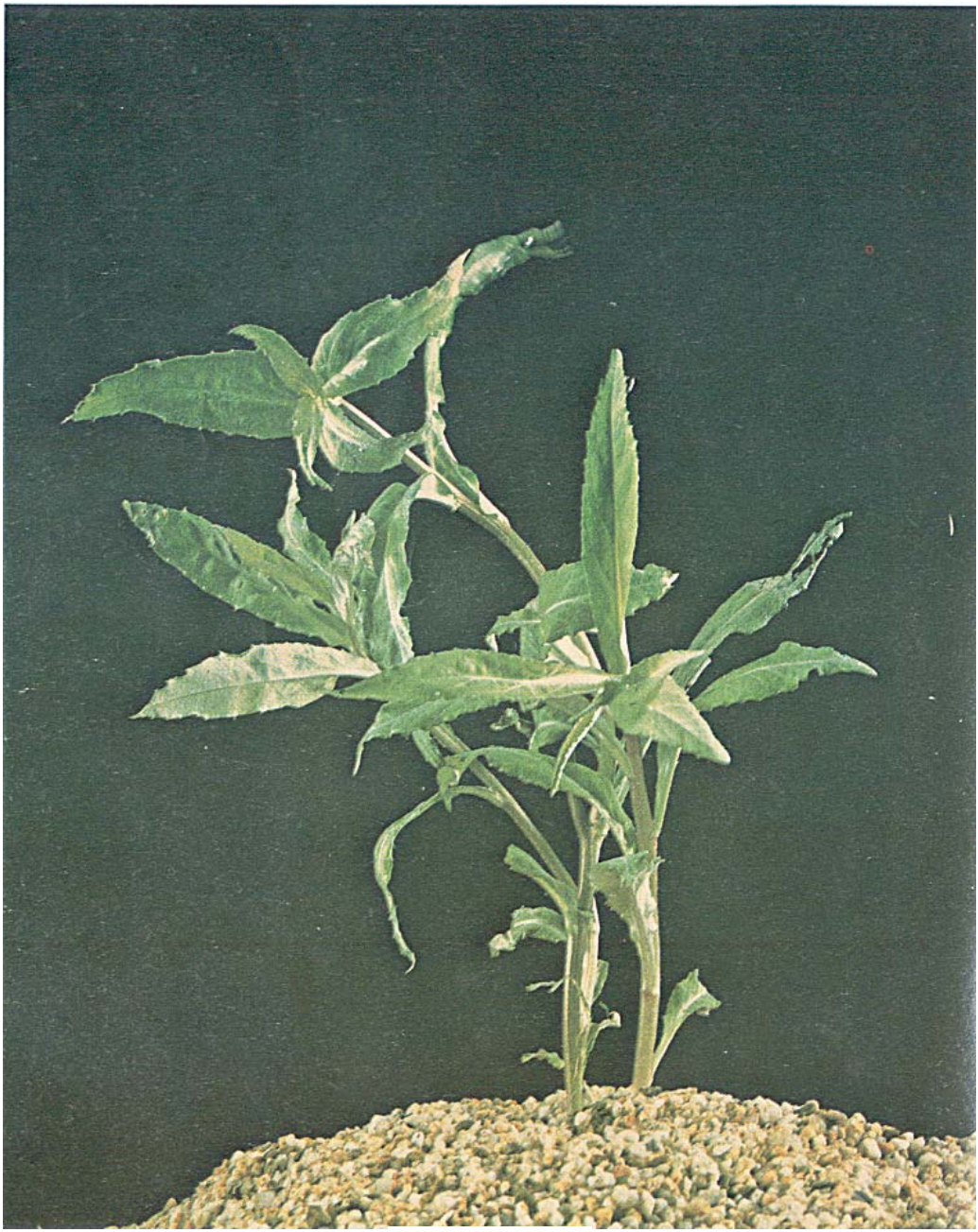
LOBELIA CARDINALIS L. (Ill. 352, 353)

L. cardinalis is native to the United States, where it grows from the temperate zone to the warm areas of Florida. In emersed form it develops erect stems with alternate, lanceolate leaves. The flowers are very decorative, bright red. For this reason it is often cultivated in gardens. Emersed plants are propagated; the vegetative tips (10 to 15 cm long) are transplanted under water. Plants from gardens or natural environments are not suitable for this purpose. Only plants that are grown in high humidity (such as a greenhouse) can be transplanted under water. Submersed plants are usually sold under the incorrect name of "*Cryptofolia*." Under water they grow rather slowly; but with aged water, good lighting, and a neutral pH, they usually grow better. *L. cardinalis* is planted into groups with three to five stems. Under water the stems are white-green and the leaves are bright green, longer and wider than in the emersed forms, usually 5 to 10 cm long. The margins are dentate.

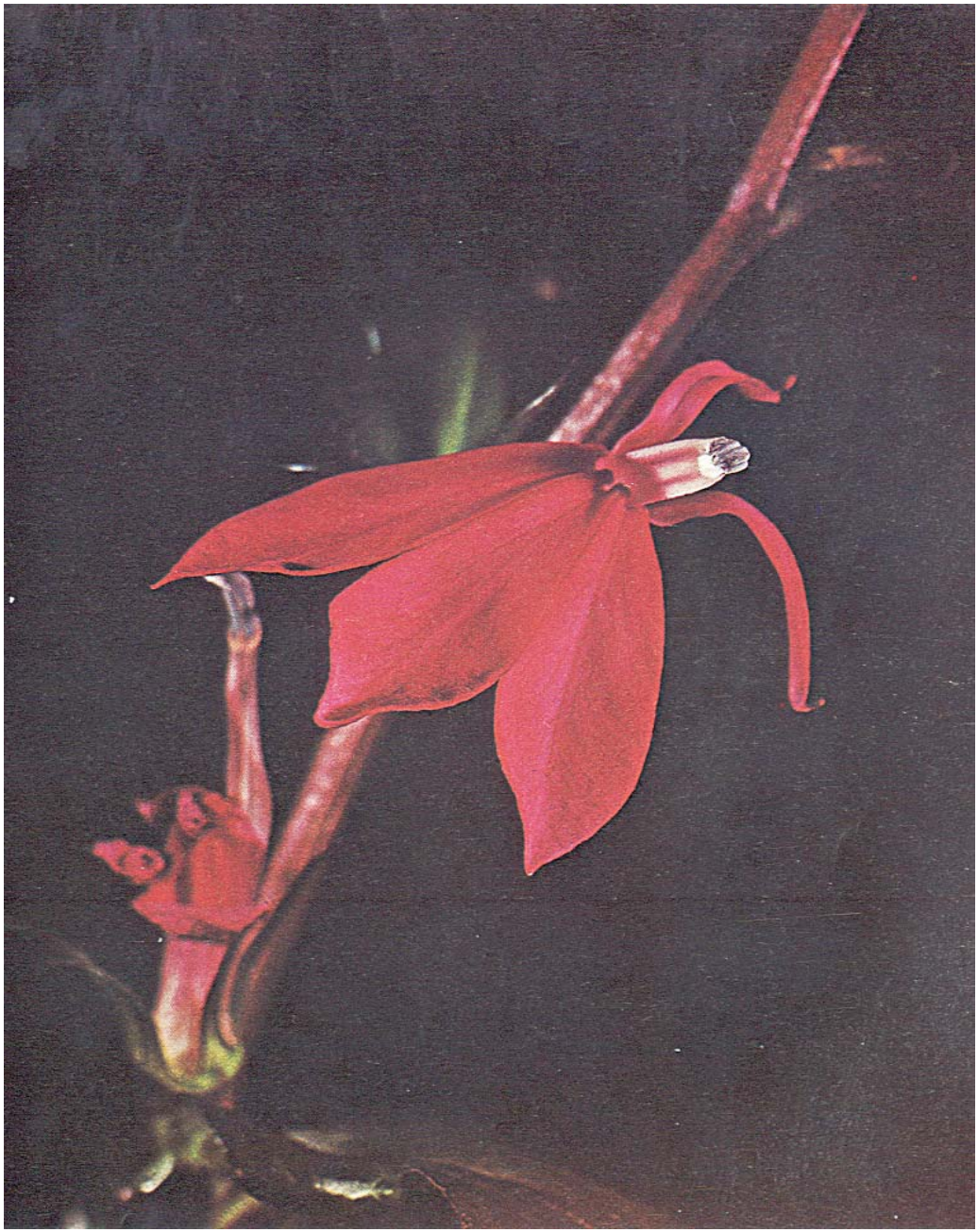
LOBELIA SPLENDENS Willd. (Ill. 340)

This species from Mexico differs from *L. cardinalis* in being more robust and reaching up to a meter in height. The stems of *L. cardinalis* have underwater leaves that are always arranged alternately, while *L. splendens* in submersed conditions forms rosettes of leaves that are bright green or red and up to 10 cm in length.

L. splendens is cultivated in the same way as *L. cardinalis*. It tolerates being in half-shade and adapts well to the warm water of a tropical aquarium.



Lobelia cardinalis.



Flower of *Lobelia cardinalis*.



Ammania senegalensis

LYTHRACEAE (Loosestrife Family)

The Lythraceae comprises herbs, bushes, or trees with opposite leaves (rarely whorled). About 500 species in 25 genera are known, the majority of which are found in the tropics (especially in America), with a few in the temperate zone. Only three marsh genera (*Ammania*, *Rotala*, and *Lythrum*) are distributed in both hemispheres. Seven genera of this family contain aquatic plants. Only *Ammania*, *Didiplis*, and *Rotala* are cultivated.

AMMANIA

Thirty *Ammania* species are known coming from the swampy areas of America, Africa, Asia, Australia, and Europe. They usually have an erect stem, leaves that are smooth-edged, grass-green, and oppositely arranged. Inconspicuous flowers are formed at the axil of the leaves. Of several plants tested, *A. senegalensis* or *A. latifolia* were found to be the best.

AMMANIA SENEGALENSIS Lam. (Ill. 354, 356)

This species is distributed in the northern parts of Africa and is also found as a weed in rice fields. The creeping stem (usually reddish) is 2.5 to 5 mm thick. There are three varieties known: one with green leaves, another with narrow leaves, and a third one with wide red leaves. Those plants with green leaves are not suitable for aquariums because they do not grow permanently under water. The leaves of the red varieties are ovate, 25 mm long and 10 to 12 mm wide, and their margins are undulate (the broad-leaved variety). The leaves of the narrow-leaved variety are about 50 mm long and 7.5 to 10 mm wide, with nearly curled margins. The flowers are pink or reddish and 5 to 7.5 mm wide.

An *Ammania* plant is cultivated in a poor substrate in soft or medium hard water with a good light. In winter it must be provided additional artificial light, otherwise the lower leaves drop so that at the beginning of spring the existing tips have to be cut off and replanted. If it grows well under water in summer, the tips can be pruned and the main stem will then branch out; in this way bright green, very ornamental bushes can be obtained.

DIDIPLIS DIANDRIA (Nutt. ex DC.)

Syn: *Peplis diandria* Nutt. ex DC.

This is the only species of *Didiplis* found in America; it occurs in the United States, from states in the temperate zone to Texas and Florida and in Mexico. *D. diandria* is an aquatic or a marsh plant. The stem is densely leaved, prostrate in emersed plants, and floats in water; the leaves (15 to 25 mm long) are linear, green, opposite, arranged cross-wise, and so dense that the stem resembles a spruce branch. Sessile reddish flowers are formed regularly under water. This is one of the most beautiful plants in our aquariums.

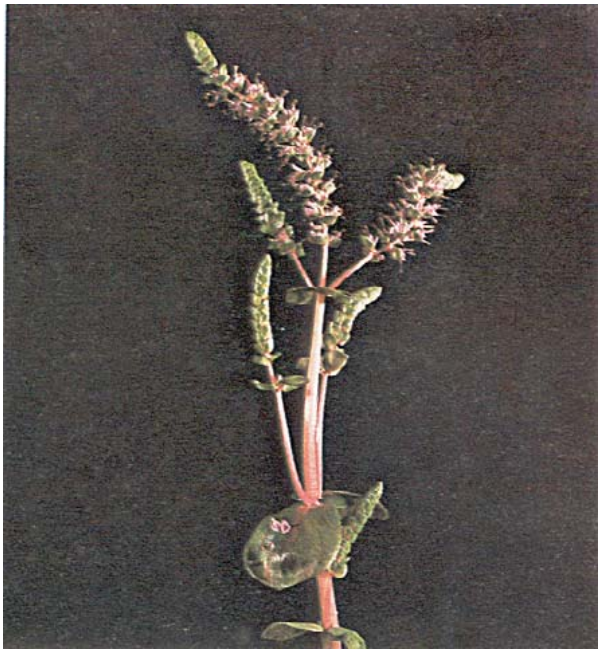
The plant is cultivated in soft to medium hard water in a reasonable light, but artificial light will also do. It requires temperatures about 68° F (20° C), but withstands colder as well as very warm water without being damaged. This species grows relatively slowly. The plant is propagated by planting broken fragments of the stem.

ROTALA

Rotala is widely distributed all over the world and contains fifty species. All the species are aquatic or amphibious. Many of them are found as weeds in rice fields and irrigation channels.



Ammania senegalensis, submersed plant.



Inflorescence of
Rotala macrantha.

Rotala macrantha. Photo by Rodney Jonklaas.



ROTALA ROTUNDIFOLIA (Roxb.) Koehne
Incorrect name: *R. indica* Koehne (Ill. 359)

R. rotundifolia comes from India and is found mainly in rice fields. Along with the cultivation of rice it has been dispersed over a wide area, reaching as far as the Caspian Sea.

Emersed stems are creeping, up to one meter long, and take root easily. Leaves are about 15 mm long and 12 mm wide, opposite, round, and without petioles; the lower surface reddish with very distinct veins.

After transplanting to an underwater environment, dissimilar leaves are formed on the stems; the leaves are narrowly lanceolate, opposite, and arranged cross-wise. The upper surface is olive-green, while the lower surface is red-brown. Submersed plants develop very well and branch abundantly, especially if their growing tips are cut off.

R. rotundifolia and *D. diandria* are cultivated under the same conditions, but *R. rotundifolia* does well in any kind of water and is less particular as to light.

ROTALA MACRANTHA Koehne (Ill. 357)

This plant is similar to the preceding species, but the leaves are larger (up to 10 to 25 mm long), wide, rounded not only in emersed but also in submersed cultures, and red-brown to light red. Growth is not fast. It is cultivated in half-shade with cryptocorynes.

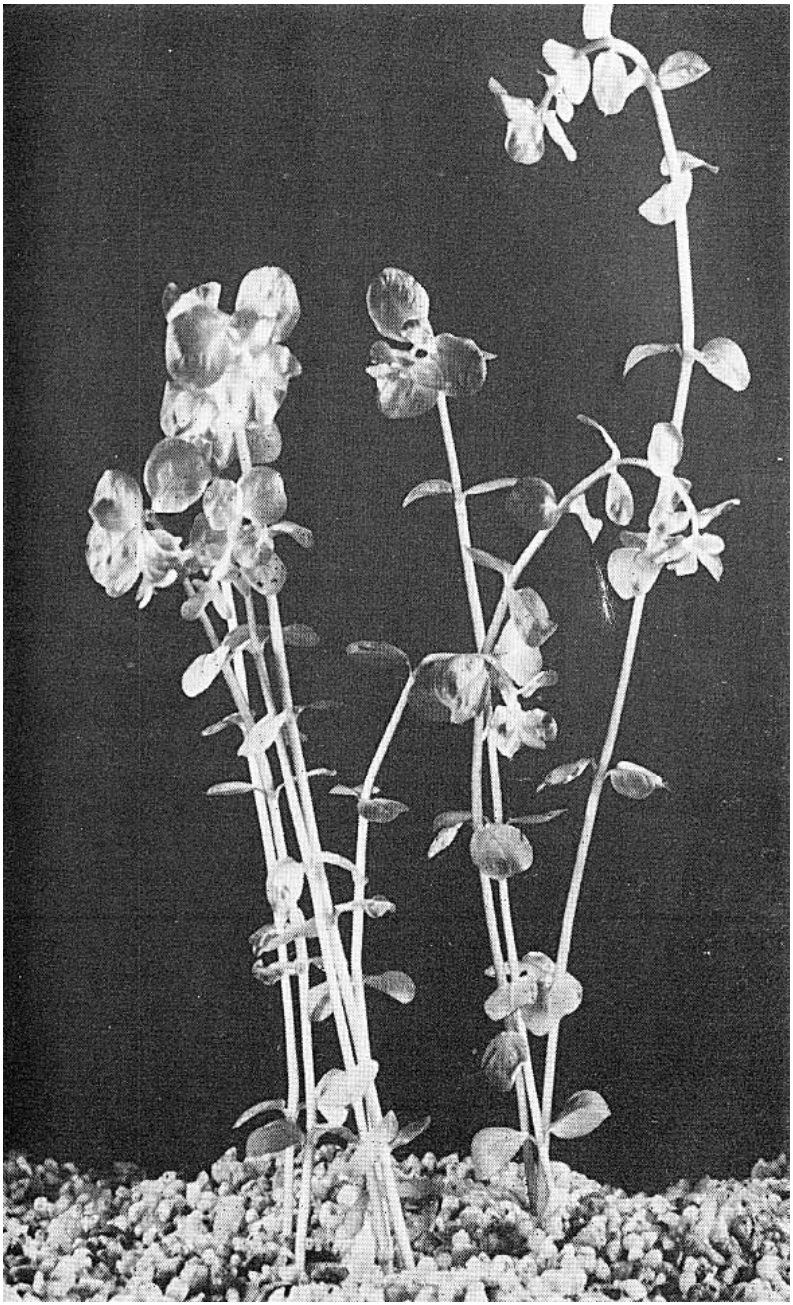
ROTALA WALLICHII (Hook. f.) Koehne
Incorrect name: *Mayaca* sp. from India

In recent years this plant has been imported from India and is usually offered under the incorrect name *Mayaca*. Submersed *R. wallichii* resembles *Mayaca* greatly. Leaves in whorls are 10 to 12 mm long and only 1.25 mm wide, green or brown-green, and the tips are often reddish or yellow-gold. The inflorescence above the surface is similar to other species of *Rotala*. The flowers in whorls are light lilac.

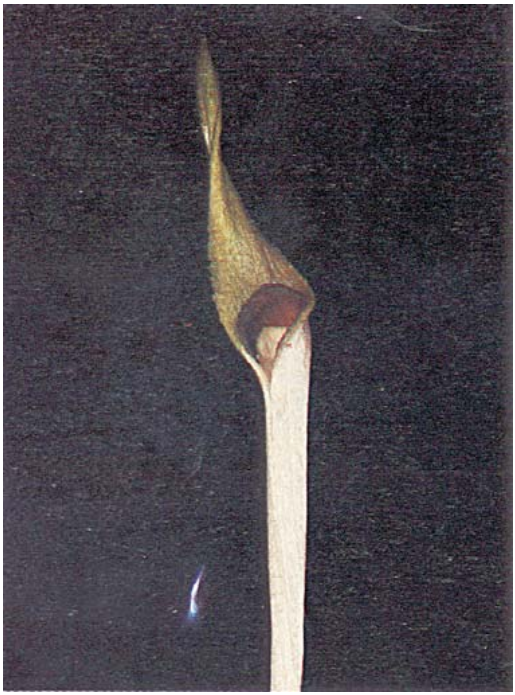
Cultivation is similar to that of *R. rotundifolia*.

MAYACACEAE (Ill. 341)

This family comprises of the unique genus *Mayaca* with about ten species. They are found in America, from the southeastern United States to Paraguay, and in Angola (Africa). The stems are submersed, floating, or creeping; leaves are linear, very narrow, and arranged spirally. Flowers are white, pink, or violet and 10 to 15 mm wide.



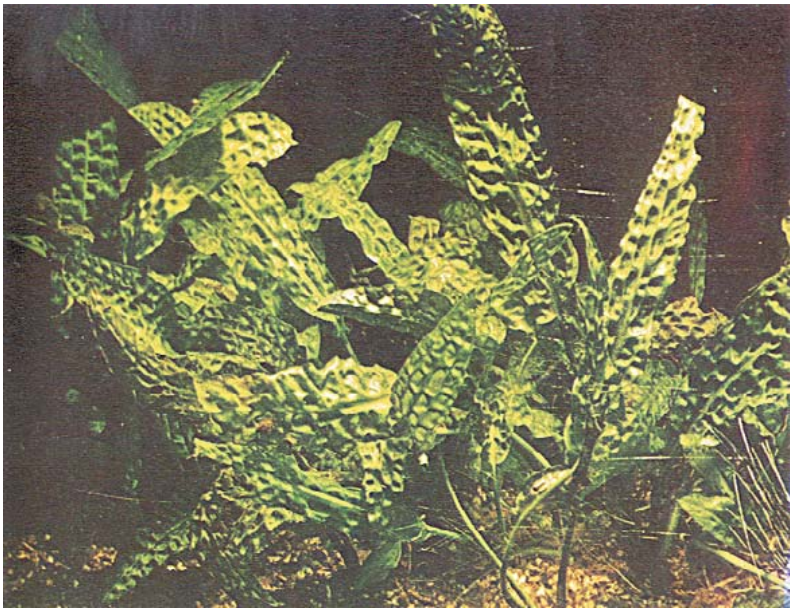
Rotala rotundifolia.



Inflorescence of *Cryptocoryne beckettii.*

Cryptocoryne beckettii.





Cryptocoryne bullosa var. *bullosa*. Photo by T.J. Horeman.

Flowering plants of *Cryptocoryne ciliata* photographed in Thailand. Photo by T.J. Horeman.



Mayaca plants are occasionally imported, but being very fine and fragile they usually arrive damaged. We do not have enough experience with the cultivation of this genus. The best known species is *Mayaca sellowiana* Kunth.

MENYANTHACEAE (Buckbean Family)

Species floating on the water or growing amphibiously on the banks represent the family Menyanthaceae. There are about forty species and five genera. The genera *Nephrophyllidium, Menyanthes,* and *Liparophyllum* have one species each, *Villarsia* has sixteen species, and *Nymphoides* about twenty species. These are distributed mainly in the tropics and subtropics, but they also reach the temperate zone.

Most species of the genus *Villarsia* come from Australia. They are thermophilic marsh plants with beautiful yellow flowers suited for indoor cultivation under marsh conditions. Submersed they stay healthy only if given good daylight conditions.

The genus *Nymphoides* (= *Limnanthemum*, floating heart) is the only typical aquatic member of the whole family.

NYMPHOIDES (FLOATING HEART)

Plants of the genus *Nymphoides* are perennial aquatic plants developing long, thin petioles from a stiff rhizome. The leaf blades are submersed (though usually floating on the surface) and round or oval with the base sometimes cordately incised. Leaves are 5 to 10 cm long according to the species. Their flowers are campanulate, up to 50 mm long and bright yellow or white with fringed petals.

They are cultivated in deep, well illuminated aquariums; in shallow water they form floating leaves that are not too suitable for aquariums. Altogether about twenty species are known. In the temperate zone only a single species, *N. peltata* (Gmel.) O. Kuntze, is found, but it is not fit for the aquarium. *N. indica* (L.) O. Kuntze and *N. cristata* (Roxb.) O. Kuntze are common weeds in rice fields. (Ill. 349)

NYMPHOIDES AQUATICA (Walt.) O. Kuntze (UNDERWATER BANANA PLANT) (Ill. 12)

N. aquatica comes from the United States, where it grows in shallow waters up to a depth of 60 cm. The rhizome is formed by elongated tubers (banana-shaped and in bunches) from 2 to 4 cm long. In winter the plant forms wide blades that are submersed and 5 to 10 cm long. These are green, cordate, and rounded with a lobate base and undulate margins. In summer the blades are float-

ing and 10 to 15 cm long. The upper surface is bright green while the lower surface is purplish red and covered with spongy tissue.

The flowers grow 20 to 40 mm below the leaf blade (on the petiole) and are campanulate, white, fringed on the margins, and 15 to 20 mm in diameter. In this position the roots and leaves grow; young plants arise by this method.

N. aquatica can be cultivated permanently submersed in very poor sand and in very dark situations. If too much light is received, it forms floating leaves that shade the whole aquarium.

NYMPHOIDES HUMBOLDTIANA (Kunth) O.K.

Submersed leaves are formed by this plant only for a short period, therefore it is cultivated in greenhouse pools for its numerous beautiful lace-like white flowers with very long fringes on the margins.

NAJADACEAE (Pondweed Family)

This family (with only a single genus) consists of submersed annuals usually rooted in the ground; the tropical species do well in the aquarium. The plant is profusely branched, with simple leaves that are either opposite or in whorls. Simple, minute flowers (monoecious or dioecious) arise at the axil of the leaves.

NAJAS

About fifty species of najas are known from the tropics, subtropics, and temperate zone. The leaves are linear, with dentate and serrate margins. Najas can be found in freshwater lakes and ponds as well as in brackish waters of rivers. They are not exacting plants; some species grow very fast, very soon overcrowding an aquarium and therefore are used only as spawning plants for fish. Others grow more slowly and are successful aquarium plants. Propagation is by stem division.

They require generous lighting. Some species have no special requirements as to temperature (from 59° to 77° F, 15° to 25° C), while others grow best at temperatures above 77° F (25° C). They will also grow floating freely.

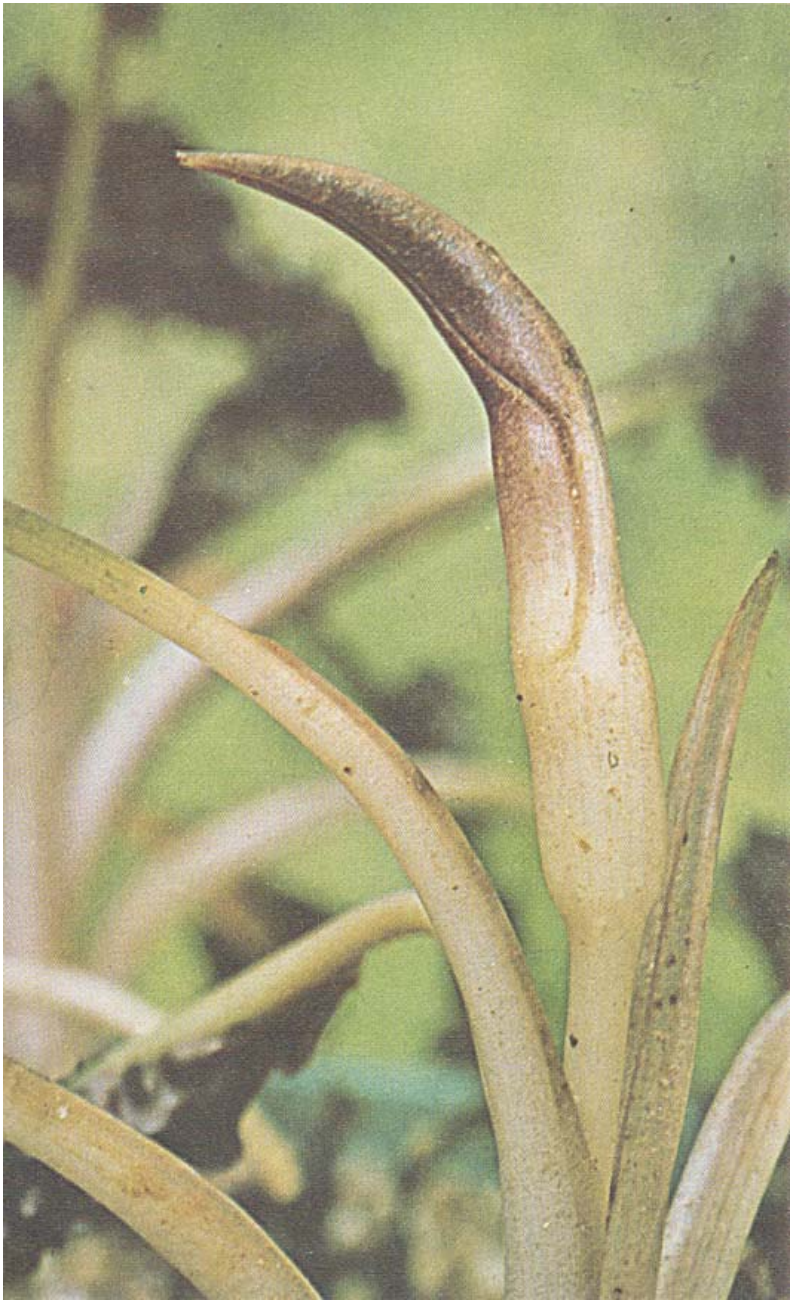
Various species, such as *Najas falciculata* Del from East India, *N. horrida* A. Br. (= *N. pectinata* Magnus) from tropical Africa, *N. guadalupensis* (Spreng.) Magnus from America, *N. interrupta* K. Schum. from Africa, and *N. madagascariensis* Rendle from Madagascar, are not suitable aquarium plants; development is very fast and in favorable conditions the plants soon overgrow the whole tank. The fragile and breakable stems give rise to new plants by stem division. The most suitable species for indoor aquariums is *N. indica; N. graminea* is very good as a spawning medium.



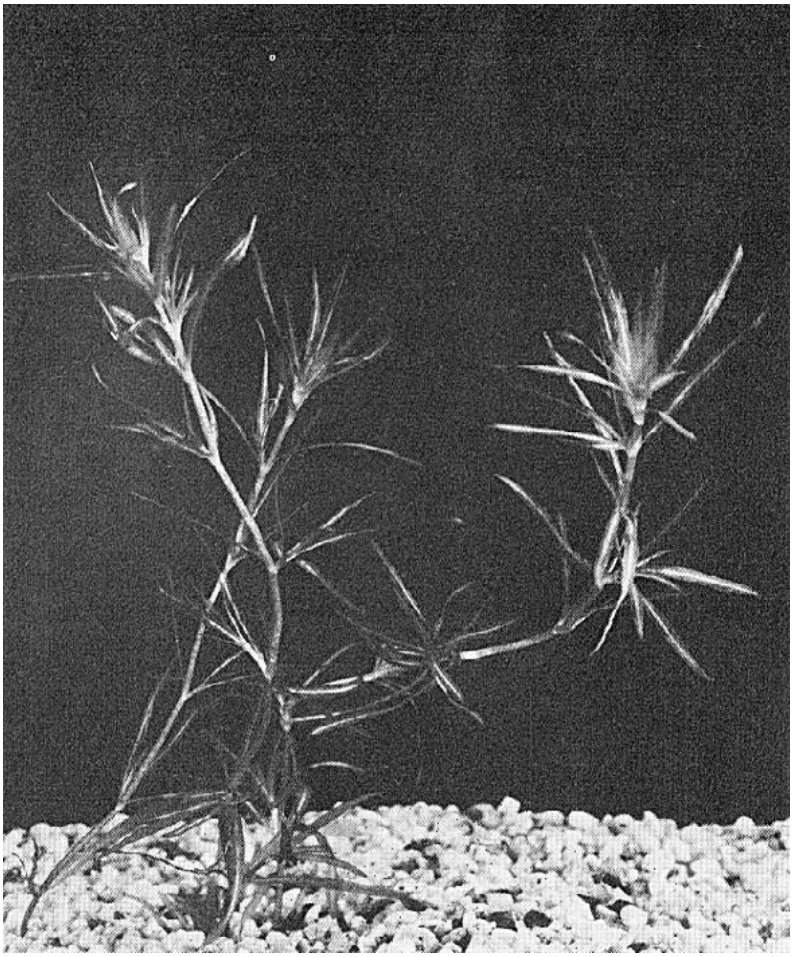
Aglaonema species with inflorescence collected in Brunei, Borneo and photographed by T.J. Horeman.

Collecting cryptocorynes in a river in Malaya. Some plants are seen partially emersed on a sand bank. Photo by T.J. Horeman.





Inflorescence of *Cryptocoryne bullosa*. Photo by T.J. Horeman.

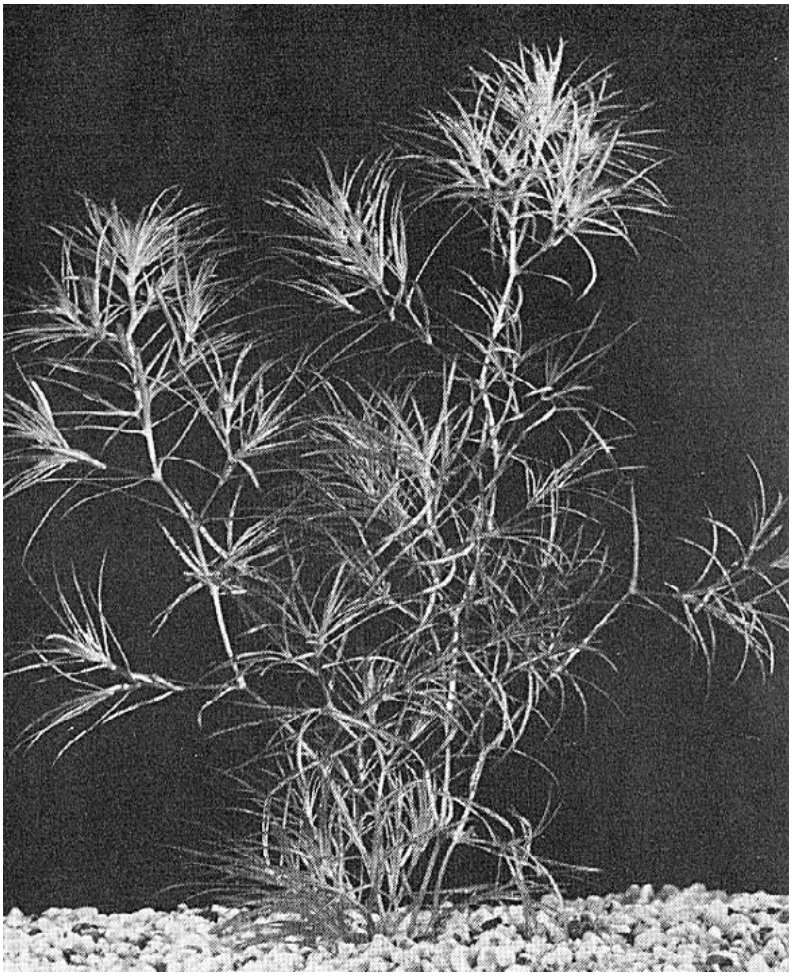


Najas graminea.

NAJAS GRAMINEA Del. (Ill. 366)

N. graminea grows in the Mediterranean area, in subtropical and tropical Africa, in Asia, and in Australia. In nature the stems reach a length of 70 cm and are profusely branching from the very bottom and densely leaved. The leaves are narrowly linear (15 to 25 mm long) with strongly undulate margins having thirty to fifty very fine denticles. The species can be identified very easily by this characteristic.

In the aquarium the stems of *N. graminea* are very fragile and their fragments (10 to 15 cm long) form dense, light green, usually

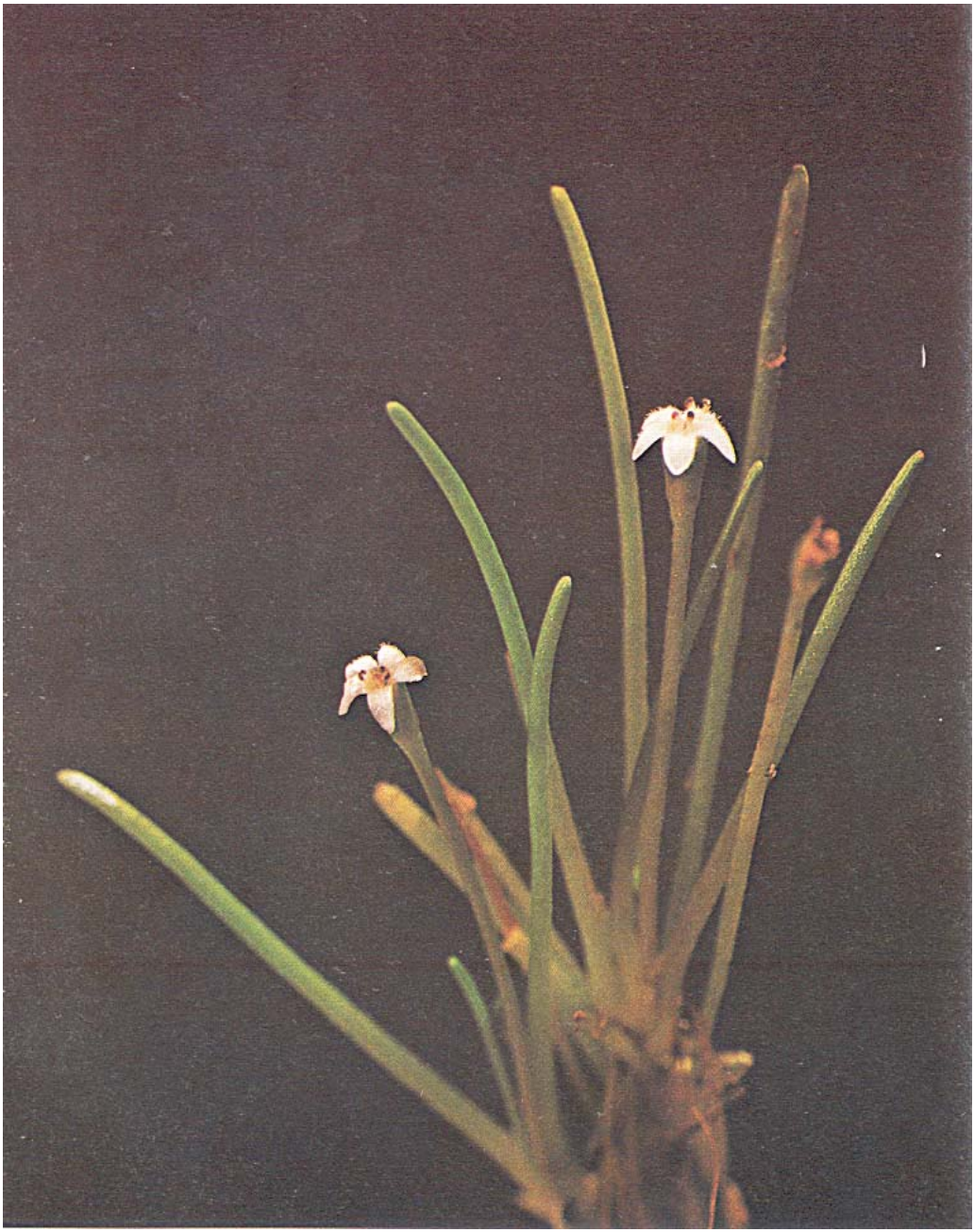


Najas indica.

unrooted tufts. The plant requires soft water, tolerates bright as well as fairly shady conditions, and grows well even in winter.

NAJAS INDICA (Willd.) Cham.
Syn: *Najas kingii* Rendle (Ill. 367)

This plant from tropical eastern Asia has underwater stems that are almost unbranched, but above the surface they are very profusely branched. Leaves are narrowly linear, up to 35 mm long, falcate, and bright green; the leaf margins have sixteen to nineteen teeth that are never longer than half the width of the blade.



Flowering *Limosella subulata*.



Rorippa aquatica, cultivated submersed.

N. indica is the most beautiful representative of the family. It requires soft or medium hard water and either a fairly good light or at least not too much shade. Decorative tufts are formed, while the stiff stems are relatively firm (not fragile). Even if fully floating it grows well and is propagated by means of fragments detached from the stems.

NYMPHAEACEAE (Water-lily Family)

The family Nymphaeaceae is represented by typical aquatic plants which are distributed everywhere in the tropical, subtropical, and temperate zones. The greatest number of these plants are found in the tropics. External organs of this family are most varied. Some plants are entirely submersed, such as the beautiful *Barclaya.* Altogether six genera with 65 species are known.

The major part of the water-lily family develops submersed leaves only for a temporary period (in the beginning of spring before the stage of sexual maturity). The typical leaves float on the surface of the water, as in the genera *Nymphaea, Nuphar, Victoria, Brasenia,* and others. Only the genus *Nelumbo* (lotus) forms emersed leaves growing out of the water on long petioles. The land forms of *Nuphar* are dwarf plants and clearly do not thrive well.

Most of the species in this family belong to the genus *Nymphaea* (water-lily) with 40 species. They are well known beautiful flowering plants with floating leaves. Some of them flower in the daytime, others at night. All of them require a resting period either at low temperatures or away from the water in dry or moderately moist sand. They are therefore of no use in the aquarium. In addition they are large plants; a single plant normally requires 10 to 30 square feet of surface area. An exception is the dwarf water-lily, *Nymphaea baumii* Rehn. et Henkel., whose floating leaves are only 20 to 30 mm long. There is another somewhat bigger horticultural hybrid, *Nymphaea daubenyana,* with leaves that are about 10 cm long. *N. daubenyana* forms only floating leaves, but the delicate blue flowers are very decorative and aromatic as well. Propagation is simple; new plants arise on the base of floating leaves. *N. lotus is a* unique species of water-lily that is commonly cultivated in aquariums.

BARCLAYA LONGIFOLIA Well. (Ill. 349, 373)

The most beautiful of the Nymphaeaceae in our aquariums originally came from Thailand and Burma. It is, however, a very exacting plant. Rhizomes are formed from which a rosette of leaves

develops; these leaves are lanceolate, 30 cm long and 25 to 40 mm wide, cordate at the base, and gradually taper toward the apex. The upper surface of the leaf is glossy green or brown-green, while the lower surface is deep red-purple. They are very thin, nearly pellicular, and with moderately undulate margins.

A solitary flower, which opens on the surface of the water, is formed on the scape. The upper surface of the petal is purple-red, the lower surface greenish. Flowers are self-fertile and are pollinated even if the flower never reaches the surface or fails to open (this is the general rule in aquariums). Seeds are softly prickly and germinate well.

Barclaya requires a fairly rich soil without too much lime, soft water, and sufficient light. It thrives best in aquariums with illumination coming from above. The fine leaves are easily damaged by snails and fish and the plant is consequently not suitable for aquariums that are well stocked with fish.

It is exacting with respect to the temperature, which is the greatest drawback, requiring 77° to 86° F (25° to 30° C) to flower and produce seeds. For growth *Barclaya* needs a minimum of 68° F (20° C); the plant does not thrive at lower temperatures and generally dies at 59° F (15° C).

Three other species of *Barclaya* come from Southeast Asia, but only *B. mottleyi* is imported to Europe. We have not been successful in the cultivation of this species.

NUPHAR
(YELLOW POND-LILY, SPATTERDOCK)

Nuphar is distributed mostly over maritime areas of the temperate zone, although some species extend considerably toward the north. They grow in still or slowly moving waters, usually of a rather deep nature. Whereas the genus *Nymphaea* develops floating leaves soon after germinating, *Nuphar* generally grows for two to three years as a submersed plant and only then develops floating leaves and flowers. The submersed leaves are quite different from those formed on the surface. Being light green, pellicular, and fragile, they appear quite decorative alongside the grass-green leaves of other plants.

Specimens obtained from seeds can be kept submersed in the aquarium for several years. In nature floating leaves appear only on plants growing in still waters, while in sufficiently fast running waters old plants (2 meters tall) can be found flowering abundantly and possessing only submersed leaves. These robust plants are not suitable for transplanting into an aquarium.



Flowers of *Nuphar luteum*.

Nuphar luteum.





Barclaya longifolia.

The yellow water-lily is propagated from seeds. By dividing the rhizome one can cultivate tall, well developed plants that, however, do not take root but die after consuming all the food reserves.

Seeds collected from nature or the aquarium are hibernated in water at a temperature around 41° F (5° C). In early spring they are sown on the surface of a bed of fine sand at a temperature of 64° to 68° F (18° to 20° C). Germination is quick and the seedlings take root; upon reaching a height of about 50 mm they are transplanted into water 10 to 20 cm deep and later, when they are about 10 cm tall, finally placed in the aquarium.

Nuphar species are cultivated in a fairly rich medium in a well lighted situation; they are not particular with regard to temperature. In nature they have a period of rest in winter; since they are not from the tropics, they often die because of high temperatures and a short day which do not suit them. On account of the latter point they should be given additional artificial light in winter.

About twenty species, all capable of cultivation in aquariums, are known. In Europe there are strictly speaking two native species, of which *N. luteum* is the most common species. The yellow water-lilies do not flower in aquariums and are identified only with difficulty.

NUPHAR LUTEUM (L.) Smith (Ill. 372)

N. luteum grows in Europe, North Africa, and northern Asia. Plants living in nature reach a height of about 2 meters. Submersed leaves are round, with the leaf base cordately or sharply incised; in the aquarium they are generally 10 to 15 cm in diameter, light green, moderately undulate, and with petioles twice as long as the blade. It is cultivated in a tolerably rich medium with adequate illumination. This plant can stand lower temperatures (about 53° to 59° F, 12° to 15° C) but does best at 68° to 77° F (20° to 25° C). In dark aquariums it often dies in winter, especially young seedlings with insufficiently developed rhizomes.

NUPHAR PUMILUM (Timm.) D.C.

This species is found in central and northern Europe and in Siberia. The flowers are conspicuously smaller than *N. luteum*, but otherwise resemble it very strongly. In the aquarium the two species are not distinguishable. *N. pumilum* is not suitable for indoor aquariums. In nature it grows in cool places, so the plant can not endure warm water (above 68° F, 20° C); it can be induced to hibernate only with difficulty.

NUPHAR SAGITTIFOLIUM Pursh.

N. sagittifolium is native to South Carolina in the United States and belongs to the subtropical group of aquarium plants. The most beautiful *Nuphar,* it is very rarely seen in European aquariums. The leaves are long, arrow-shaped, much longer than the petiole (up to 50 cm long), which varies according to the depth of the water. The leaf blade is 20 to 40 cm long, its base 7 to 10 cm wide. The whole leaf surface is strongly undulate, with the margins curved upward. Leaves are light green and pellucid. This species does not produce floating leaves and is fully adapted to submersed existence, thus it is of greater value to aquarists.

It withstands high temperatures (to 82° F, 28° C) very well and hibernates very well, too. A most beautiful and rewarding aquarium plant which however does not usually flower in the aquarium and is propagated only with great difficulty. The plant requires soft, moderately acid or moderately alkaline water and generous light; mature plants are not sensitive to the composition of the substrate.

NYMPHAEA LOTUS var. *JAPONICUS* Hort. (Ill. 376, 377)

As far as it is known this is a unique species of *Nymphaea* fit for aquariums. We are not sure if it is really the species *N. lotus.* If the plant receives enough light; it forms floating leaves and consequently is not fit for aquariums. If it is cultivated only in the shade to half shade (lit from the side, not from above), only submersed decorative leaves are formed. The leaves are 20 to 30 cm long; their petioles are about twice as long as the blades, which are membranous, transparent, round, with pointed lobes at the base, at the most 10 cm long and about the same width, with distinct nerves. There are several very colorful varieties. The basic forms have green blades, but some varieties have red-brown blades or green blades with brown spots.

In containers well illuminated from above, floating leaves develop instead of submersed ones and possibly flowers. The flowers are 75 mm in diameter, snow-white, and open at night. They only open in the morning for a short period, then close. The flowers are self-fertile, so it is possible to collect from each bloom several hundred seeds that are easily germinated. However it takes a long time to cultivate seedlings, so the generative mode of propagation is seldom used. *N. lotus* is propagated by very long root-runners, at the tips of which new plants arise vegetatively. The leaves, being membranous, fragile, and soft, are very often damaged by water snails.



A horticultural variety of *Nymphaea lotus* var. *japonica*.



A horticultural variety of *Nymphaea* species called pink pearl. Photo by C.O. Masters.

NOTE: The large tropical members of Nymphaeaceae, such as *Victoria* and *Euryale*, are only suitable for large tropical ponds. The smallest species of *Nymphaea*, *N. micrantha* Guill. and Perr. (only 50 mm tall), has not yet been imported to Europe. Another very interesting plant is *Ondinea purpurea* Hartog from northwestern Australia. It is similar to *Barclaya longifolia* and occurs in small streams, up to 60 cm depth, that dry out for five to seven months of the year. During the dry period it aestivates as corms. Its cultivation is still unknown. See the family Cabombaceaea for the genera *Cabomba* and *Brasenia*.

ONAGRACEAE (Oenotheraceae) (Evening Primrose Family)

This family consists of annual to perennial herbs, also (rarely) bushes and trees. The family is divided into more than twenty genera with about 650 species, the majority of which come from the temperate to the subtropical zone of the Americas (principally California, Mexico, and Brazil); few are found in the tropics. Many of them are well-known indoor flowering plants, such as the South American genus *Fuchsia*. Africa, Asia, and Europe are relatively poor in representatives of this family. Many of the species are cultivated in gardens and rockeries. Some species grow on river banks, but only *Ludwigia* can grow permanently under water.

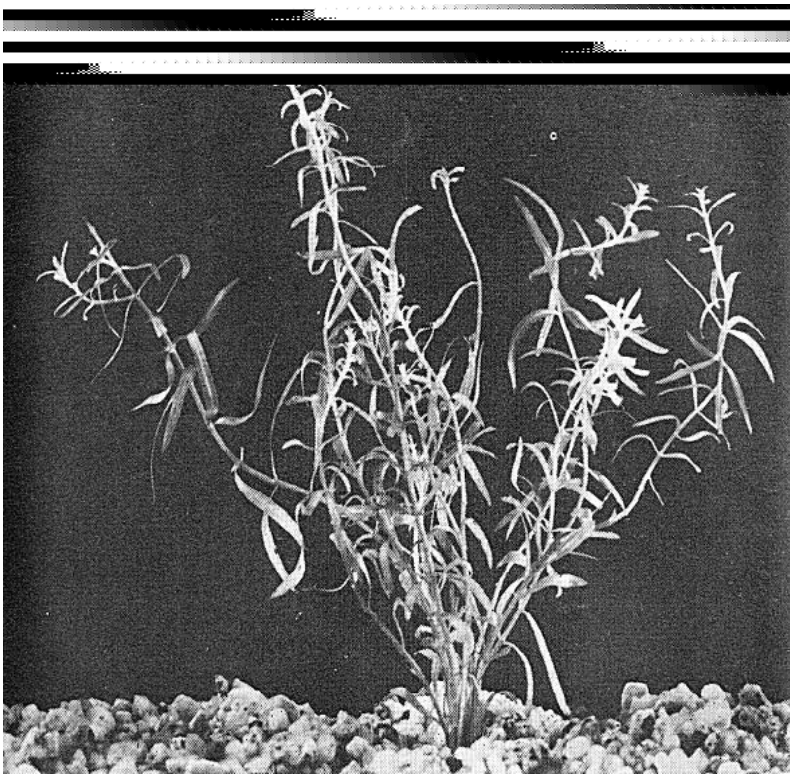
LUDWIGIA (FALSE LOOSESTRIFE) (Ill. 71)

Ludwigia has small, inconspicuous flowers and is mainly found in North and South America. Only a few species grow in tropical Africa, Asia, and Australia, while only one species is found in Europe.

In aquariums or terrariums they should be cultivated on medium rich to poor substrates. The plants can stand hard water, but grow better in soft water, and require a generous light and temperatures from 54° to 77° F (18° to 25° C). Note that *L. palustris* growing in Europe is even fit for coldwater aquariums. Propagation is accomplished by planting the stem cuttings. When cultivated as an emersed form, they flower readily and produce seeds, but cultivation from seeds is a lengthy process. Only the following plants are of practical use for indoor aquariums.

LUDWIGIA ARCUATA Walter

L. arcuata comes from Virginia and Florida. Emersed parts of the stems are prostrate, 30 to 60 cm long, and only the tips are erect. Leaves (15 to 20 mm long and usually only 2.5 mm wide) are green, sometimes reddish. The stems float under water, are 10 to



Ludwigia brevipes.

40 cm long, and are densely branched. The leaves are longer and narrower than with emergent forms, up to 30 mm long and only 1.2 to 1.8 mm wide, nearly linear, usually arched. Flowers are deep yellow, 15 mm in diameter.

It is best to plant *L. arcuata* in the center or in the corners of the aquarium. The tips should be pinched off as soon as they reach the surface.

LUDWIGIA BREVIPES (Long.) E.H. Eames (Ill. 379, 381)

This species occurs in nature in the area of Long Beach Island, Ocean County, New Jersey. It is an emersed form, mostly creeping, lower than the preceding species. Leaves are narrowly lanceolate but considerably wider than those of *L. arcuata*, and in emersed forms about 5 to 7.5 mm wide, in submersed forms 2.5 to 5 mm wide. The flowers are yellow, about 10 mm in diameter.



Spathiphyllum species from Guyana, South America growing amongst the trees in deep shade. Photo by T.J. Horeman.

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Inflorescence of *Cryptocoryne hejnyi*.

Cryptocoryne hejnyi.





Cryptocoryne griffithii with flower photographed in the greenhouse. Photo by T.J. Horeman.

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Cryptocoryne lingua with inflorescence and fruit.
Photo by T.J. Horeman.



Cryptocoryne korthausae.

Cryptocoryne johorensis, emersed form.



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Fruit of *Cryptocoryne lingua*. Photo by T.J. Horeman.

Cryptocoryne lingua seedling. Photo by T.J. Horeman.





Opened seed pod of *Cryptocoryne lingua* showing the ripe seeds. Photo by T.J. Horeman.

Cryptocoryne lucens.



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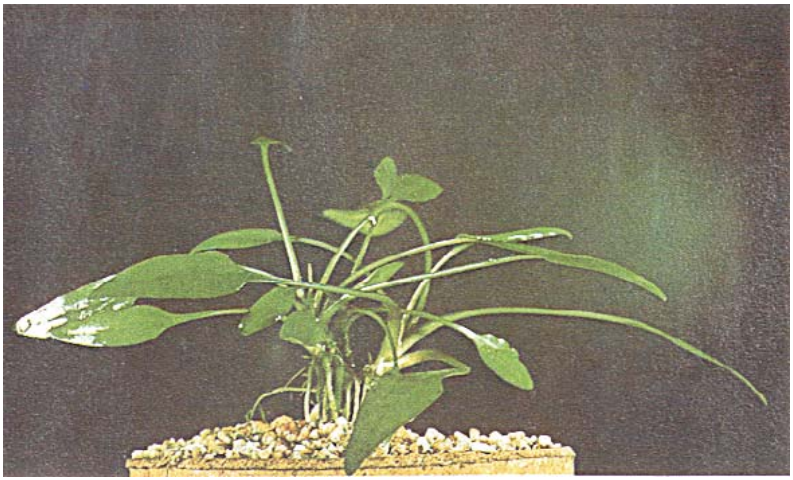
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Cryptocoryne minima with inflorescence photographed in its natural habitat in Malaya. Photo by T.J. Horeman.

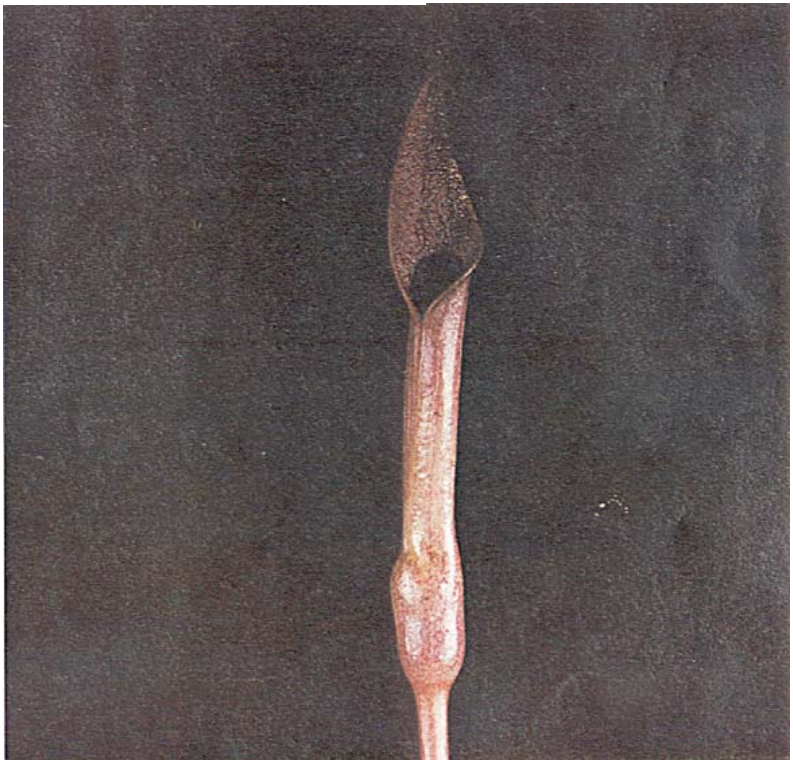
The beautiful dark red inflorescence of *Cryptocoryne nuri* from Malaya. Photo by T.J. Horeman.





Cryptocoryne nevillii.

Inflorescence of *Cryptocoryne nevillii.*



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AQUARIUM PLANTS: Their identification, cultivation and ecology

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